Electronics &
Technology Today
Canada's Magazine for High-Tech Discovery
$3.50
MM70924
APR90

Personal Cassette Amp
All About Capacitors
Surround Sound
Auto Ignitions

513735*JAN 92* ET27* *
KEVIN JOURNEAUX
68 EASTON AVE
MONTREAL WESTPQ H4X 1K8

Best
Elite 386
see page 6

DELIVERY FROM STOCK
CALL TODAY!
(416) 252-8543
OR TOLL-FREE
1-800-668-6951

THE BEST

DESIGNED AND MANUFACTURI
AND INCLUDES EXCELTRONIX'

BEST COMPACT 386SX

"Featuring a small footprint, this powerful desktop computer has the capabilities of a 386 machine at an AT price. It is an excellent choice for small business or home office use. All essential peripherals are on the motherboard, leaving six I/O slots free for further expansion."

STANDARD CONFIGURATION:

- Intel 80386SX microprocessor running at 16MHz
- 1 meg memory optionally expandable to 4 meg on board
- Socketed for 80387SX math coprocessor
- LIM 4.0 support
- Page mode interleaved memory architecture
- Motherboard also includes: two serial ports, one parallel port, real time clock/calendar, hard and floppy controller
- Phoenix BIOS
- 101 enhanced keyboard
- one 1.2 meg 5.25" or 1.44 meg 3.5" disk drive
- Our own Canadian designed and manufactured motherboard includes all above features and leaves you with six free expansion slots (five AT, one XT)
- CSA approved system

OPTIONS:

- Video display adapter (VGA, EGA or Mono)
- Video monitor (colour or mono)
- Hard disk (20 to 600Mb)
- Second floppy drive (any type)
- System board 16-bit RAM expansion to 4 Mb

386SX AS DESCRIBED ABOVE WITH
1MB RAM & 40MB 3.5" 28ms hard drive $1,895
2MB RAM & 100MB 3.5" 28ms hard drive $2,495
2MB RAM & 200MB 3.5" 38ms hard drive $2,995

BEST COMPACT 386-20

"For business applications, such as accounting, financial 'what if' modelling, desktop publishing and database operations — the Compact 386 has the speed, power and reliability to satisfy all your needs."

- Intel 80386-20 microprocessor
- 20MHz processor clock speed
- 1 meg 32-bit memory expandable on board to 8MB of 32- bit memory and up to 16 meg with our 8 meg 32-bit plug-in memory board
- Socketed for 80387 math coprocessor
- Motherboard also includes: two serial ports, one parallel port, real time clock/calendar, hard and floppy controller
- Phoenix BIOS
- 101 enhanced keyboard
- One 1.2 meg 5.25" or 1.44 meg 3.5" disk drive
- Our own Canadian designed and manufactured motherboard includes all above features and leaves you with six free expansion slots (five AT and one XT slot)
- CSA approved system

386-20 AS DESCRIBED ABOVE WITH
1 MB of RAM and 40 meg. 3.5" 25ms HD $2,495
2MB RAM and 100MB 3.5" 28ms HD $3,395
4MB RAM and 200MB 3.5" 28ms HD $3,995

BEST ELITE 386-33

"This 33 MHz zero wait state 386 tower with 32K cache memory provides superb, lightning-fast performance. Ideal for demanding power users, as a CAD/CAM workstation or flexible network server applications."

STANDARD CONFIGURATION:

- Intel 80386-33 microprocessor
- 33 MHz processor clock speed
- 32K cache memory, 0 wait state
- Socketed for the 80387 math coprocessor
- 1 meg 32-bit memory expandable on board to 16 MB of 32-bit memory
- Tower case
- 230 watt heavy duty power supply
- 1.2 meg 5.25" or 1.44 meg 3.5" floppy drive
- on board two serial ports, one parallel port and real time clock
- 8 expansion slots (six AT, two XT slots)
- Hard drive and floppy controller
- 101 enhanced keyboard
- CSA approved system
- Our Canadian designed and manufactured motherboard features the award winning LSI 386 chip set

OPTIONS:

- Video display adapter (VGA, EGA or Mono)
- Video monitor (colour or mono)
- Hard disk (20 to 600Mb)
- Second floppy drive (any type)
- System board 32-bit RAM expansion to 2, 4, 8 or 16Mb

SPECIAL: BASIC CONFIGURATION WITH:
One meg RAM $2,995
Two meg RAM and 40 meg 28ms 3.5" HD $3,795
Two meg RAM and 100 meg 28ms 3.5" HD $4,295
Four meg RAM and 200 meg 28 ms 3.5" HD $4,995

BEST ELITE 486

- Intel 80486 microprocessor (approx. 50% faster 386)
- Microprocessor Includes built-in 8K of cache memory 0 wait state and a built-in math coprocessor
- 1 meg 32-bit memory expandable on board to 16MB of 32- bit memory
- Tower case
- 230 watt heavy duty power supply
- 1.2 meg 5.25" or 1.44 meg 3.5" floppy drive
- Motherboard also includes: two serial ports, one parallel port, real time clock/calendar, hard and floppy controller
- Phoenix BIOS
- 101 enhanced keyboard
- One 1.2 meg 5.25" or 1.44 meg 3.5 " disk drive
- Our own Canadian designed and manufactured motherboard includes all above features and leaves you with 7 free expansion slots (6 AT, 1 XT)
- CSA approved system

BASIC 486 SYSTEM PRICE WITH
1 meg ram $3,995
2 meg RAM and 100 meg 28ms/ 3.5" HD $5,295
4 meg RAM and 200 meg 28ms/ 3.5" HD $5,995
NOTE: the above prices include the built-in 487 math co-processor

*** • BASIC BEST SYSTEM – 3 YEAR PARTS & LABOUR • BEST COMPUTER SYSTEM BOARDS – 5 YEARS PARTS & LABOUR • HAR**

Exceltronix Computing Inc.

Circle No. 1 on Reader Service Card

433 HORNER AVENUE, SUITE 1
TORONTO (416) 252-8543
OTTAWA (613) 235-2378
EDMONTON (403) 483-4271
WINNIPEG (204) 942-8993

RANGE

ED IN CANADA WITH PRIDE
3 AND 5 YEAR WARRANTY*

BEST COMPACT 286

"The most widely supported 'workhorse' in terms of speed, power and reliability, this high-performance AT-class computer meets the requirements of business, engineering and academic users now and for years to come."

STANDARD CONFIGURATION:

- 80286 microprocessor
- 12MHz and 16MHz versions available
- Math co-processor socket (80287)
- Motherboard also includes: 2 serial ports, 1 parallel port, real time clock\calendar
- 8 expansion clocks
- Floppy drive controller
- Hard drive controller
- Phoenix BIOS with setup program
- 1Mb 16-bit RAM
- 1 floppy disk drive
- Heavy duty power supply
- 101-key enhanced keyboard
- Keyboard lock and status display
- CSA approved

OPTIONS:

- Video display adapter (VGA, EGA or Mono)
- Video monitor (colour or mono)
- Hard disk (20 to 320 Mb)
- Second floppy drive
- System board 16-bit RAM expansion to 4 Mb

12MHZ VERSION WITH 1 meg. RAM with 40 meg. 28ms 3.5" hard drive $1,395

16MHZ VERSION WITH 1 meg. RAM with 40 meg. 28ms 3.5 inch HD $1,405

BEST PERFORMER 286

"A fast and powerful 'entry level' desktop computer, fully compatible with hundreds of MS-DOS software applications. It more than meets the needs of students and professionals as a powerful tool for word processing, graphics, programming and more."

STANDARD CONFIGURATION:

- 80286 microprocessor
- 12MHz clock speed
- Math co-processor socket (80287)
- Motherboard also includes: 2 serial ports, 1 parallel port, real time clock/calendar
- 10 year life for CMOS RAM battery
- Floppy drive controller
- Hard disk controller
- Phoenix BIOS with setup program
- 640Kb 16-bit system board RAM, expandable to 1MB
- 3 free expansion slots (2X16-bit, 1X8-bit)
- 1 floppy disk drive
- 101-key enhanced keyboard
- Case and keyboard lock
- Status display
- CSA approved system

OPTIONS:

- Video display daughter card (EGA or TTL Mono)
- Video display adapter (VGA, EGA or Mono)
- Video monitor (colour or mono)
- Hard disk (20 to 200Mb)
- Second 3.5" floppy drive (720Kb or 1.44 Mb)
- Expandable to 2 or 4Mb on motherboard with daughter card

PERFORMER 286 as described above with: 40MB 28ms 3.5" Hard Drive $1,095 1 meg RAM 100MB 28ms 3.5" Hard Drive $1,795

BEST PERFORMER 88

"Primarily used as an intelligent terminal in local area networks or for access to mini and mainframe systems, this XT-class desktop computer is equally capable for stand-alone applications."

STANDARD CONFIGURATION:

- 8088 microprocessor / 10MHz
- Math co-processor socket (8087)
- Motherboard includes: 2 serial ports, 1 parallel port, real time clock/calendar
- Floppy drive controller
- Hard disk controller
- Phoenix BIOS
- 640 Kb system board RAM
- 3 free expansion slots
- 1 floppy disk drive (360 Kb or 720 Kb)
- Heavy duty power supply
- 101-key enhanced keyboard
- Case and keyboard lock
- Status display
- CSA approved system

OPTIONS:

- Video display daughter card (EGA or TTL Mono)
- Video display adapter (VGA, EGA or Mono)
- Video monitor (colour or mono)
- Hard disk (20 to 200Mb)
- Second 3.5" floppy drive (720 Kb)

) DRIVES & OTHER PERIPHERALS CARRY THE ORIGINAL MANUFACTURER'S WARRANTY

2, ETOBICOKE M8W 4Y4

FAX (416) 252-5124
MONTREAL (514) 849-5872
HALIFAX (902) 454-0052
TOLL FREE ACROSS CANADA 1-800-668-6951

***LEASING AVAILABLE**

THE BEST SPECIALS

AVX 386-16 MHz**
with 1 MEG RAM
40 MEG Hard Drive
1.2 MEG Floppy Drive
$1,495

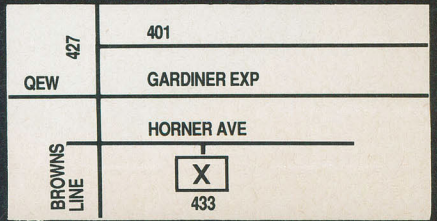
COMPACT 286-10 MHz**
with 640 K RAM
40 MEG Hard Drive
1.2 MEG Floppy Drive
$995

**THESE SYSTEMS COME WITH ONE YEAR WARRANTY
LIMITED QUANTITY
C.O.D. ONLY

VIDEO DEALS

BEST EGA Video w/ ROLAND DC355 Monitor
$595

COME AND VISIT OUR NEW SHOWROOM AT 433 HORNER AVE. SUITE #12 ETOBICOKE, AND TEST FLY OUR NEW 386's AND 486's



EASY ACCESS BY TRANSIT, ISLINGTON SUBWAY, TAKE THE 110A BUS TO, BETA STREET STOP

What do Toshiba notebook computers have in common with their owners?

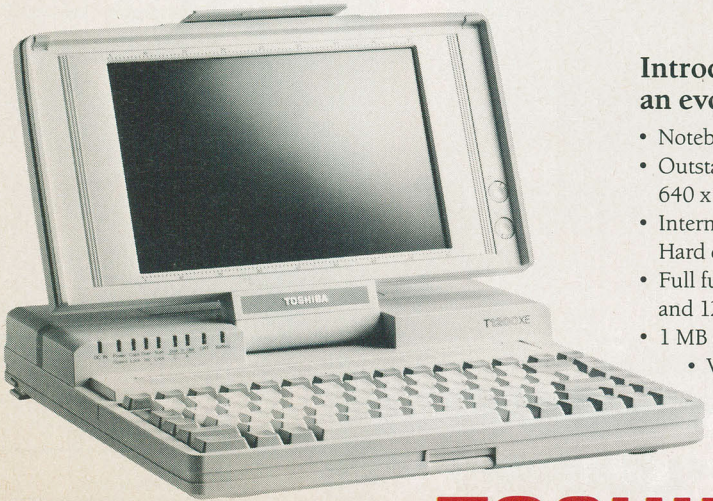
They both excel at what they do.

More than a century ago, Toshiba established itself as a leader in technological innovation. Since then, the name has become synonymous with uncompromising quality and a high standard of excellence. So, it's not surprising that Canadians who demand a lot of themselves, choose Toshiba as their laptop/portable computer. They know they can depend on Toshiba's history of quality, outstanding price/performance and state-of-the-art technology. For more information about Toshiba's notebook PC's and Canada's entire "first family" of laptop/portable computers, contact your nearest Canadian Authorized Toshiba Re-Seller, or call Toshiba direct at 1-800-387-5645.

Canadians know the difference!

Introducing the 1000XE – the lightweight heavyweight with internal hard disk drive!

- Notebook 80C86 computer
- Outstanding backlit electroluminescent LCD display with 640 x 400 resolution
- MS-DOS and File Transfer software in ROM (Read Only Memory)
- Fast Internal 20 MB hard disk drive
- 1 MB standard RAM memory expandable to 3 MB
- Full function keyboard features dedicated cursor control keys and 12 function keys
- Weighs less than 6 lbs.
- Uses Toshiba's outstanding array of battery conservation techniques including – "AutoResume Mode"



Introducing the 1200XE – an evolution in notebook computing!

- Notebook 80C286 computer
- Outstanding sidelit fluorescent LCD display with 640 x 400 resolution
- Internal 1.44 MB 3.5" Floppy disk drive and fast internal 20 MB Hard disk drive
- Full function keyboard features, dedicated cursor control keys and 12 function keys
- 1 MB of RAM memory standard, expandable to 5 MB
- Weighs less than 8 lbs.
- Uses Toshiba's outstanding array of battery conservation techniques including "AutoResume Mode"

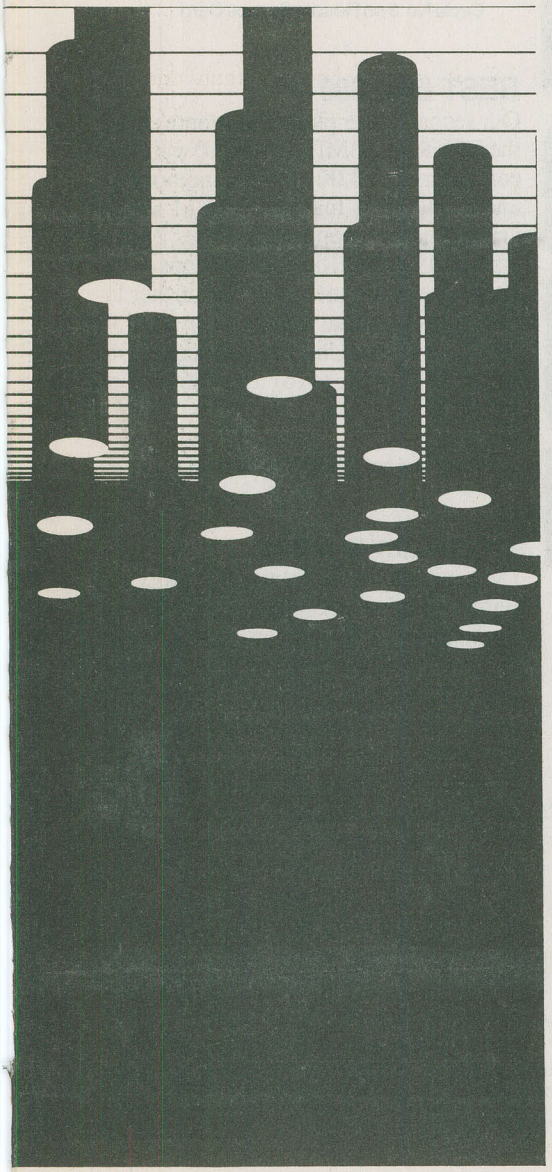
TOSHIBA

INFORMATION SYSTEMS DIVISION

Circle No. 2 on Reader Service Card

Electronics &
Technology Today
Canada's Magazine for High-Tech Discovery
Volume 14 , Number 4 April, 1990

FEATURES



Basic Electricity, Part 3 20
Continuing our tutorial on basic circuits .
Techie's Guide to C Programming, Part 16 8
Steve Rimmer's popular guide to C.
Designing with Logic, Part 3 36
Hardware and software apprroaches to logic circuits.
Capacitors and Capacitance 10
Surround Sound 24
Car Electronic Ignition Systems 28

PROJECTS

Personal Cassette Amplifier 26

INFORMATION

For Your Information 6
Advertisers Index 18

Cover photo courtesy of Tektronix Canada.

Electronics & Technology Today

Electronics & Technology Today
is published 12 times a year by:
Moorshead Publications Ltd.
1300 Don Mills Road, North York, Ontario M3B 3M8 (416) 445-5600 FAX: (416) 445-8149

Editorial Director:	Frank Lenk
Editor:	William Markwick
Publisher:	Kenneth Marskell
Director of Production:	Papu Leynes
Art Direction:	Kevan Buss
Circulation Manager:	Sharon Cernecca
Advertising Manager:	Paul Smith
Manager, Marketing and Sales Promotion	Kim Rattray
Production:	Richard Rawlins
President:	V.K. Marskell
Founder & Chairman	Halvor Moorshead
Vice-President—Sales:	Allan Wheeler
Vice-President—Finance:	Bernie Shankman
Office Manager:	Pirjo Dunphy
Reader Services:	Rick Cree
Advertising Services:	Michelle Millett Carmela Parzanese

Newsstand Distribution:
Master Media, Oakville, Ontario

Subscriptions:
$22.95 (one year), $37.95 (two years).
Please specify if subscription is new or a renewal.
Outside Canada (US Dollars). U.S.A. add $3.00 per year. Other countries add $5.00 per year.

Electronics & Technology Today
is indexed in the Canadian Magazine Index by Micromedia Ltd.
Back copies are available in microfilm form from Micromedia Ltd. 158 Pearl Street, Toronto, Ontario M5H 1L3 (416) 593-5211.

Printed by:
Heritage Press Ltd., Mississauga, Ontario

ISSN 07038984

Moorshead Publications also publishes PETS Magazine, Computers in Education, Computing Now!, Business Computer News, Business Computer Reseller News, Government Purchasing Guide and VIDEO Trade.

Circulation independently audited by MURPHY & MURPHY Chartered Accountants.

Postal Information:
Second Class Mail Registration No. 3955.
Mailing address for subscription orders, undeliverable copies and change of address notice is:
Electronics & Technology Today
1300 Don Mills Road,

FOR YOUR INFORMATION

COPYRIGHT
All material is subject to worldwide copyright. PCB designs are copyright and may not be sold without permission.

LIABILITY
No responsibility whatever is accepted for failure of projects to perform for any reason, and no responsibility is accepted for any injury or damage caused by any fault in design.

EDITORIAL QUERIES
We cannot answer telephone queries. Written queries must be accompanied by a stamped, self-addressed envelope, relate to recent articles and must not involve the staff in research.

PCB SUPPLIERS
We do not supply printed circuits or kits, and we do not keep track of availability. However, PCBs for projects are available from the following mail order sources:

B-C-D Electronics, PO Box 6326, Stn. F., Hamilton, Ontario L9C 6L9.

K.S.K. Associates, PO Box 266, Milton, Ontario L9T 4N9.

Spectrum Electronics, 14 Knightswood Crescent, Brantford, Ontario N3R 7E6.

GeoDyssey Electronic Development Inc., 8744 Greenall Avenue, Burnaby, B.C., Canada V5J 3M6.

High Performance LCDs
EEV has developed high performance Liquid Crystal Displays; a twisted nematic and a supertwist. Both displays provide higher contrast and a brighter display than conventional LEDs. The twisted nematic displays are available in positive or reverse; the supertwist come in a wide range of stahdard or custom dot matrix formats in yellow, blue, purple or B&W. EEV Canada Ltd., 67 Westmore Drive, Rexdale, Ontario M9V 3Y6, (416) 745-9494, Fax 745-0618.

Circle No. 3 on Reader Service Card

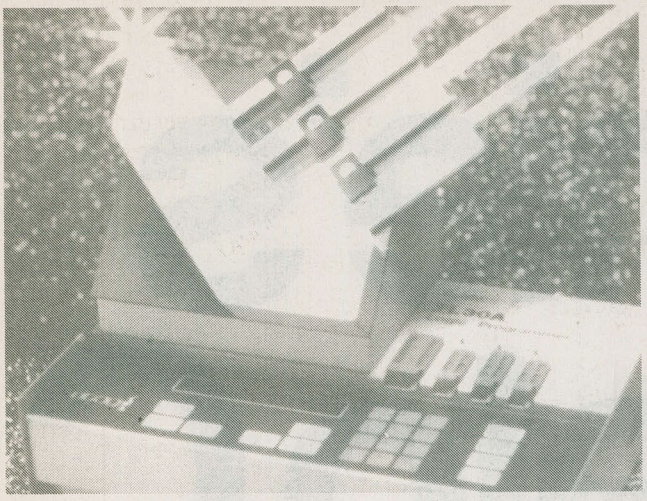
BEST Elite 386
Our second cover photo this month shows the BEST 386 33MHz tower, a 0 wait state computer with 32K of cache memory for under $4000. It features 1 1.2M floppy drive (other types optional), 8 slots, 2 serial ports and 1 parallel port, and options of 1 to 32M of onboard memory. For further information, contact Exceltronix, 433 Horner Avenue, Unit 12, Etobicoke, Ontario M8W 4Y4, (416) 252- 8543, Fax 252-5124.

Circle No. 4 on Reader Service Card

Image Conversions
The time and cost of entering pre-typed manuscripts into a computer can be almost eliminated with Scan-it, an image conversion service from the Zeppelin Corporation in Toronto. Your pages of typing are scanned and automatically converted into the format of your choice, including all popular word processor files for MS-DOS and Macintosh systems. In addition, drawings can be converted into 18 different image formats, such GIF, IMG, HPGL, PCX, etc. Two levels of scanning are available: 99% accuracy and 99.9% accuracy. Further, you can even fax your documents to them; software utilities convert the fax coding to the desired file format without the necessity of printing them out on paper. Zeppelin Corporation, 1170 Bay St., Suite 110, Toronto, Ontario M5S 2B4, (416) 967-5677.

Circle No. 5 on Reader Service Card

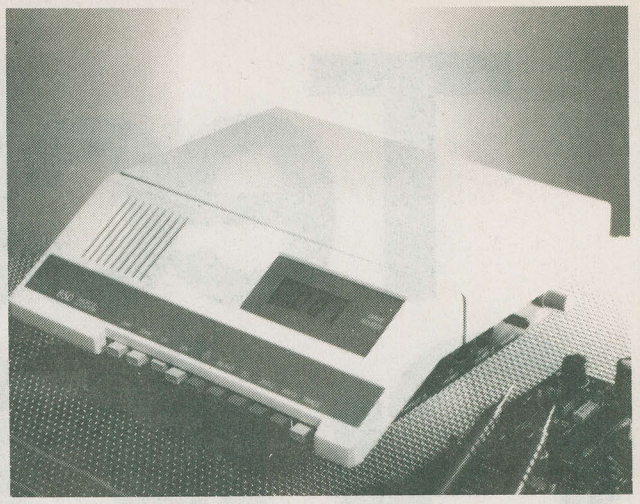
For Your Information



Surface Mount Handler

Stag introduces a low cost handler for SMD programming, the Tangent, which entirely eliminates physical handling of surface mount devices during programming. It will interface to other manufacturer's programmers as well as Stag's range, such as the ZL30/A and System 3000. Contact Allan Crawford Associates, 5835 Coopers Avenue, Mississauga, Ontario L4Z 1Y2, (416) 568-2020, Fax 890-1959.

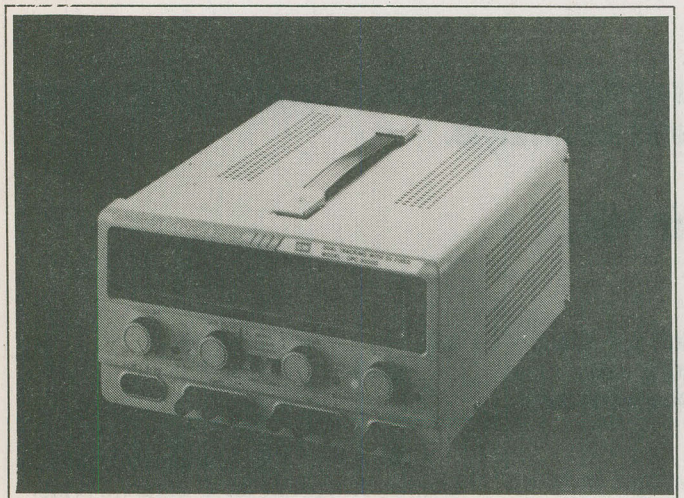
Circle No. 6 on Reader Service Card



Shorts Locator

That's what Polar Instruments have called it. The Model 850 Shorts Locator can find faults in printed circuits without cutting prints or using other damaging techniques. It uses low resistance measurement, current tracing and low value voltage measurement. In all three test modes the operator has a choice of audible tones or digital readout. Contact Cyprus Products Inc., 7648 Heather St., Vancouover, BC V6P 3R1, (604) 327-8814, Fax 327-7769.

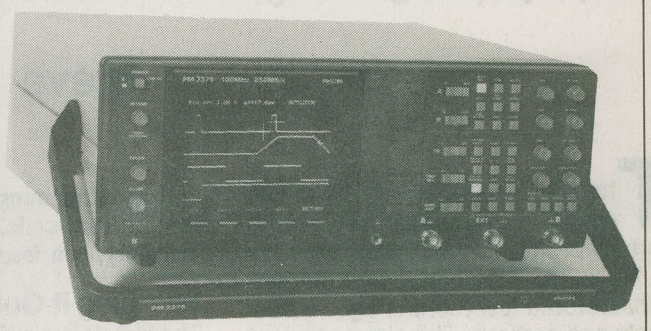
Circle No. 7 on Reader Service Card



New Power Supplies

Goodwill Instruments have introduced the GPR-Series (single output) and the GPC-Series (triple output). The supplies offer exceptional regulation (0.01% or better), constant current and voltage modes, digital or analog metering and low ripple and noise. Contact Duncan Instruments, 121 Milvan Drive, Weston, Ontario M9L 1Z8, (416) 742-4448, Fax 749-5053.

Circle No. 8 on Reader Service Card



A/D Storage Scopes

The PM3355 storage scope offers real time sampling of up to 250 MS/s, analog and digital bandwidths up to 100MHz, microprocessor calculated measurements, cursors and full autoset. The PM 3375 adds four 4K memories, 150MHz trigger bandwidth and post-triggering capability to 5,000 divisions. Fluke Electronics, 400 Britannia Road E, Unit #1, Mississauga, Ontario L4Z 1X9, (416) 890-7600, Fax 890-6866.

Circle No. 9 on Reader Service Card

FEATURE

Techie's Guide to C Part 16

This month we'll look at a complex function for getting input. More than simply a prompt and a prayer, this get string function asks for characters in style.

Steve Rimmer

There are a number of functions which are common to many of the sorts of programs which get written in C. Trolling for DOS files, something we considered a few months ago, is certainly one of them. The simple task of asking a user for in input string is another.

If you've perused the documentation for your C compiler, you'll probably know that the standard C library provides a function for getting a string, either from the console... in this case the keyboard... or from a file. This function is, predictably, a bit crude. There are a number of ways to improve on it, of which the one we'll look at this month is probably the most elegant.

In most cases, the user interface of a program occupies well over three quarters of the programming effort involved and of the resultant code. Getting string input elegantly, then, is something worth doing.

Stringing it Out

The simple get string function provided with C is called *gets*. Its operation is pretty uninvolved... you pass it a pointer to a string and it waits for input. Everything typed by the user of your program will wind up in the string until the first time a carriage return comes down the pipe.

If you wanted to, you could easily write a function to do this.

```
gets(s)
char *s;
{
while((*p++=putchar(getch())) !=
13);
    *p=0;
    }
```

Note that the function *putchar*... another denizen of the C library... prints the character passed to it to the screen and then returns the character, allowing us to devise this rather elegant structure.

There are a number of problems with this function. To begin with, it allows your users to enter anything they like into your string, whether or not it's what you had in mind. They can enter more data than you've allowed for in allocating the string passed to *gets*, in which case they'll probably manage to trash the stack of your program and do something nasty. Finally... and perhaps more important from the

point of view of being elegant and civilized... this function provides no editing facilities.

If you've used DOS for a while and have installed one of the extended command line editors... DOSEDIT or something similar... you'll probably appreciate how primitive a simple function like this can be in real life. If someone types a long string into it and discovers that there's a typo at the beginning of the string, there's no way to back up and fix the problem. We can improve on this slightly by adding a backspace facility to it.

```
gets(s)
char *s;
{
int c,i=0;

do {
c=getch();
if(c==8 && i 0) {
--i;
putchar(8);
putchar(32);
putchar(8);
} else p[i++]=putchar(c);
} while(c != 13);
p[i]=0;
}
```

There are a few things you'll want to know in order to make sense of this. The ASCII value for the backspace key is eight, and if you print character eight to the screen the cursor will backspace by one position. If you print eight, followed by thirty-two... a space... followed by eight again, the cursor will back up, erase the most recent character and then back up again.

This function does allow you to backspace and fix your errors, but it means retyping a whole line if you discover that there's an error at the beginning.

The Better Gets

A *gets* function which allowed for editing of inputted lines, something like what BASIC and DOSEDIT implement, would be a great improvement over this. Unfortunately, such a function is a bit of a pig to write. Being able to insert text into the middle of a string, manage extended editing keys and so on are all a bit demanding of your code.

You might want to consider the program accompanying this article to get a feel for the magnitude of the task. This is, I think, the ultimate get string function. It allows for full line editing... having typed something you can cursor back through the line to insert, delete or change characters. It also allows your program specify a default string to be edited, trashed or accepted by your users.

In order to avoid confusion with the stock *gets* function, we'll call this one *get_string*. It's called as

```
get_string(p,dflt,n);
```

where *p* is the buffer where your gotten string will go, *dflt* is the string you'd like to appear when the function is first called and *n* is the maximum number of characters the gotten string can contain.

In many cases you won't want a default string, in which case you can just pass an empty string for this argument, that is, two double quote marks with nothing between them.

The basic structure of this rather immense function is essentially the same as that of the simple *gets* function, although it checks for a lot more characters. One of the important things about this function is that it uses *GetKey*, rather than *getch*, to get keyboard characters. This is done because *getch* can only return stock ASCII characters, while many of the editing functions, such as the cursor mover keys, are handled by some of the extended keys of the PC keyboard. This is handled a bit oddly... if you call *getch* and it returns zero, there's the scan code of an extended key waiting in the keyboard buffer, in which case you should call *getch* a second time to retrieve it. This is essentially what *GetKey* does.

There are a few other ancillary functions involved in this code, such as the ones which change the size of the cursor. These use INT 10H BIOS calls, something we haven't really discussed as yet. You can look up what they do in a PC hardware manual if you like, you you can just trust 'em for the time being.

One of the interesting things about this enormous string getting function is that it does all its editing without actually positioning the cursor. It moves around solely by using nondestructive backspaces to move left and overprinting the existing string data to move right. This means that it doesn't care... or even actually know... where it's located on the screen. There's a considerable amount of juggling involved in making it do its stuff.

A thorough explanation of each of the cases involved in this function is beyond the scope of this article, and is probably unnecessary. If you've been following this series for the past few months, you can probably "read" C well enough to be able to walk your way through this code pretty easily. There's nothing in the least bit mysterious about how it works or what it does.

The complete string get function follows.

```
#define BS  0x08
#define CR  0x0d
#define ESC 0x1b
#define BLNK '_'

GetKey()
{
int c;

c=getch();
if(!(c & 0x00ff)) c=getch() << 8;
return(c);
}

hidecursor()
{
union REGS r;

r.x.ax=0x0f00;
int86(0x10,&r,&r);

r.x.ax=0x0200;
r.x.dx=0x1a00;
int86(0x10,&r,&r);
}

getst(size,deflt,buffer) /* get a string
*/
int size;
char *deflt,*buffer;
{
char *p;
int i,l,c,cursor=0,insert=0;

*buffer=0;
if((p=malloc(size+1))!=NULL) {
small_cursor();
for(c=0;c<size;++c) putch(BLNK);
for(c=0;c<size;++c) putch(BS);

do {
l=strlen(buffer);
if(*(deflt)==0) c=GetKey();
else c=*deflt++;
switch(c) {
case DEL:
if(cursor<l) {
memcpy(p,buffer,cursor);
memcpy(p+cursor,buffer+cur-
sor+1,(l-cursor)+1);
strcpy(buffer,p);
i=printf("%s%c",buffer+cur-
sor,BLNK);
```

continued on page 34

FEATURE

Capacitors and Capacitance

The basic operation and use of capacitors.

Michael J. Cockcroft

The sheer number of different electronic components can make our subject daunting to the beginner. If we consider the complexity of some of these components while trying to understand the basic circuit principles, we are going to get bogged down in confusing detail. This can be avoided by learning here and now that any electronic circuit or component only has one or more of three properties: they have resistance, inductance, capacitance, or a combination of these properties and bearing them in mind when analyzing circuit actions will help to keep electronics simple.

Electrostatics

Electrostatics is the science of electric charges at rest (static electricity) and is fundamental to the study of capacitors and capacitance. The first law of electrostatics is: **Like charges repel; unlike charges attract.**

A force of attraction exists between two bodies of unequal charges and a force of repulsion exists between two bodies of equal charges. This principle can be demonstrated by a simple experiment which produces static electricity: if a balloon is rubbed on woollen clothing (or your hair — especially after it has recently been washed) and touched to a wall, the balloon will attach itself to the wall. This is an example of creating electricity by applying friction energy.

Electrons are dislodged from one material and attached to the other, giving one body (the balloon or the wool) a positive charge and the other a negative charge. The wall is neutral (like all matter under naturally conditions i.e. not under the influence of an external energy) so there is a force of attraction between the two unlike bodies.

This *force* is called an **electric field**; the balloon for example, acquired a field of force around it (the lines of force will, of course, be concentrated around the area of the balloon that was rubbed) after it had been charged by friction. The greater this charge on the balloon, the greater the electric field around it; also, the electric field will disappear when the dogy losses its charge (when it is in its normal neutral state).

An electric field exists between any two different voltages. The direction of the force in an electric field depends on the polarity of the charged body. The direction is away from negative charges and towards positive charges, as shown in Fig. 1a. When two unlike charges are acting upon each other (when they are close enough together, as in Fig. 1b) the negative charge moves towards the positive charge.

With this in mind, consider the simple circuit of Fig. 2 (the "load" resistor represents any component or components as an equivalent resistance). When the switch is open there is no current flow but the battery is charged (the chemicals inside the battery force an accumulation of electrons at one terminal with respect to the other terminal — we call the force acting to convert chemical energy into electrical energy [voltage] an **electromotive force** or EMF).

When the switch is closed the electric field causes electrons in the wire to move away from the negative terminal (where they are repelled by the excess of electrons) of the battery, through the component(s), and back to the positive terminal (where they are forced by a chemical action [electromotive force] back to the negative terminal inside the battery). This movement is repeated again and again around the circuit the whole time that there is enough charge in the battery.

So *current flows from negative to positive*; but be aware that early scientists, from the results of experiments and before a true theory could be formulated, thought that current moved in the opposite direction. We call the early theory, that current flows from positive to negative, *conventional current* and many authors of electronic texts still use it today.

Capacitors and Capacitance

Capacitance exists between any two conductors in close proximity and it is the property of a circuit that causes an electric charge to be stored. Components

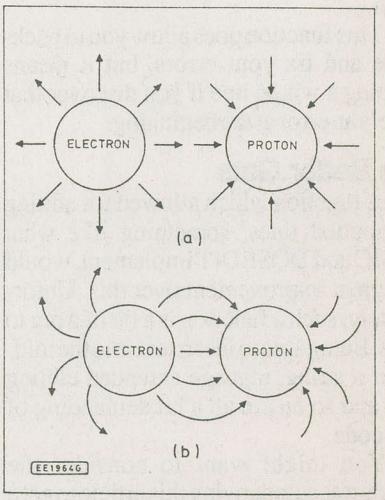


Fig. 1. The electric field.

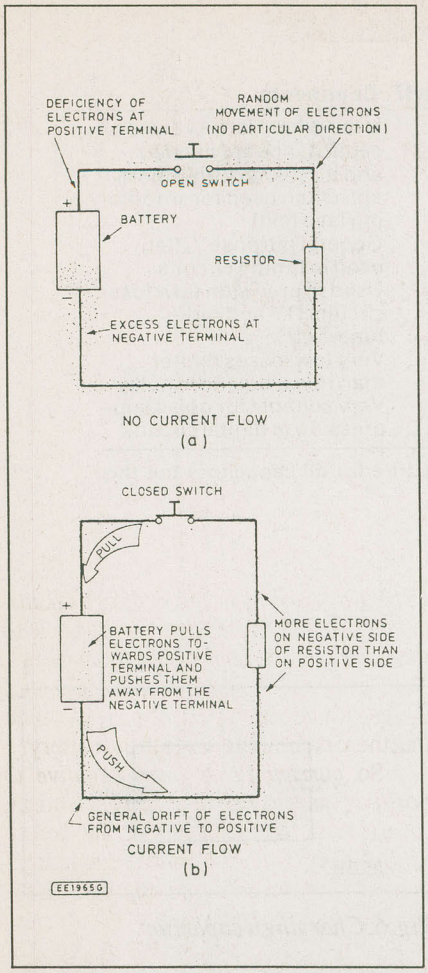


Fig. 2. Electrons in a simple circuit.

manufactured to specific values of capacitance are called *capacitors*.

Capacitors

Capacitors fall into two main groups, the *polarized* capacitor and the *non-polarized* capacitor. Electrolytic and tantalum capacitors are polarized and the correct polarity must be applied to their terminals. If a voltage is applied to the capacitor in the reverse direction the internal insulating layer, which we will talk about in a moment, will break down and short circuit the capacitor. The result will be damage to the capacitor and possibly other components in the circuit.

All polarized capacitors are clearly marked "+" and "-" on the body of the device and care must be taken that these polarities are observed when constructing circuits. Electrolytics, in particular, may explode if connected in reverse polarity to a sufficiently high voltage.

Non-polarized capacitors can be freely placed either way round into a circuit. All capacitors, however, have a maximum voltage rating; they are usually marked with their working voltages and this voltage should never be exceeded, as stated in Part 2.

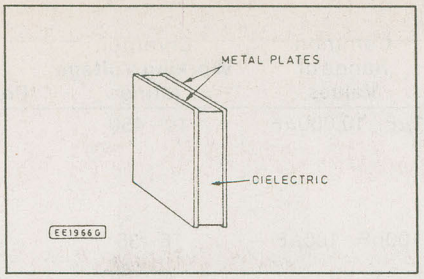


Fig. 3. Basic capacitor.

A capacitor consists of a thin strip of insulating material, known as the *dielectric*, sandwiched between two metal plates, as shown in Fig. 3. The dielectric describes the capacitor type and is often paper, air, mica, polyester or ceramic.

All capacitors have (at least) two plates and a dielectric layer. The use of a variety of dielectrics and the employment of different construction processes yield an assortment of capacitor shapes and sizes (see Table 2.5—Part 2).

High values of capacitance, in a compact form, can be achieved by rolling or stacking strips of metal foil and dielectric material, as shown in Fig. 4. Sometimes the dielectric is a paste or liquid instead of a solid; electrolyte, in the electrolytic capacitor for example, is a paste. Table 1 gives a small selection of typical capacitors with relevant comments about each (refer to Part 2 for more information including value colour coding).

Variable capacitors are also available. The dielectric in these capacitors is usually air because it is convenient to vary capacitance in variable capacitors by mechanically adjusting the distance between their plates (or the amount of overlap of the plates). The distance between the plates (which is the thickness of the dielectric) is only one of three factors that determine the capacitance of capacitors.

Capacitance of Capacitors

The capacitance value of a capacitor determines the amount of charge it is capable of storing; this depends on the following characteristics of the device: A) the area of the plates; B) the thickness of the dielectric; and C) the material used for the dielectric.

Plate Area

The value of a capacitor determines the amount of charge it is capable of holding. The amount of charge it will hold is directly proportional to the area of its plates; this stands to reason since a larger plate area holds more electrons. Fig. 5a shows that, for two capacitors with the same dielectric material and distance between the plates, the one with the larger plates has the greater capacitance.

Dielectric Thickness

The strength of the electric field between the plates depends on the distance between them; the closer the plates are together the greater the intensity of the field. The distance between the plates is, of course, a function of the thickness of the dielectric. Fig. 5b shows that, for two capacitors with the same dielectric material and plate area,

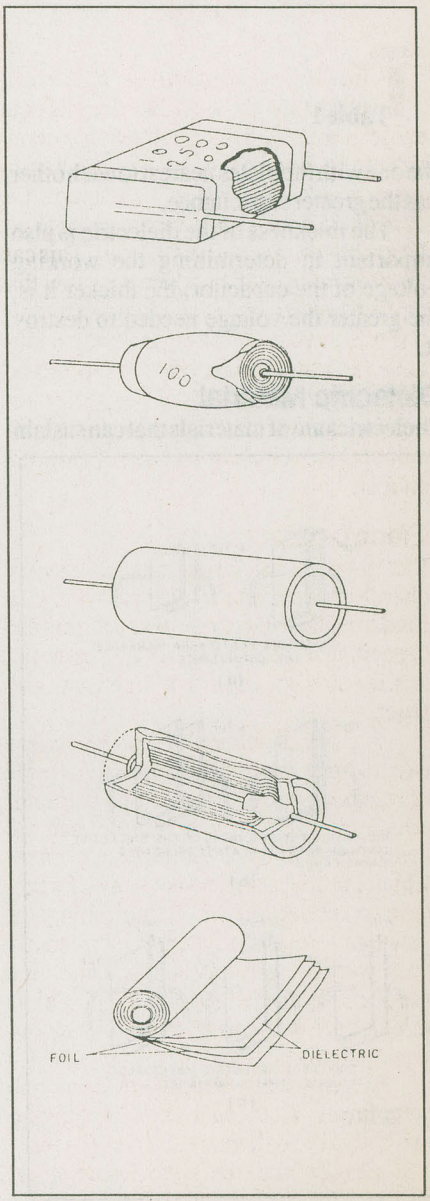


Fig. 4. Construction of capacitors.

Capicitors and Capacitance

Type	Identification	Common Range of Values	Common Working Voltage ratings	Polarised?	Comments
Electrolytic		1μF–10,000μF	10–450	Yes	Used where large values of capacitance are needed and losses *are unimportant. Often used for smoothing (see text)
Tantalum		100nF–100μF	6–35	Yes	General purpose. Often used in timing circuits
Mica (silvered)		2pF–10nF	350	No	Used in precision (low loss) circuits (TV and radio tuners etc)
Polystyrene		10pF–10nF	Up to 500	No	Very low losses (better than mica) but more bulky
Ceramic		10pF–100nF	1000V d.c. 300V a.c.	No	Very suitable for noise suppression in digital circuits

*A proportion of the energy supplied to a capacitor is lost in the dielectric. This is true for all capacitors but the amount of loss varies with the dielectric material.

Table 1

the one with the plates nearest to each other has the greater capacitance.

The thickness of the dielectric is also important in determining the working voltage of the capacitor; the thicker it is, the greater the voltage needed to destroy it.

Dielectric Material

Dielectrics are of materials that can sustain strong electric fields without breaking down. A measure of this strength is termed the *dielectric constant*. The greater the dielectric constant, the better the dielectric.

Dry air has a dielectric constant of 1, glass about 5, and mica about 7. The higher the dielectric constant for the same plate area, the greater the capacitance; for example, a 1uF air capacitor would become 7uF if a mica dielectric were placed between its plates, and 5uF for a glass dielectric. Fig. 5c shows that, for three capacitors with the same dielectric thickness and plate area, the values vary according to the dielectric constants of the different dielectric materials.

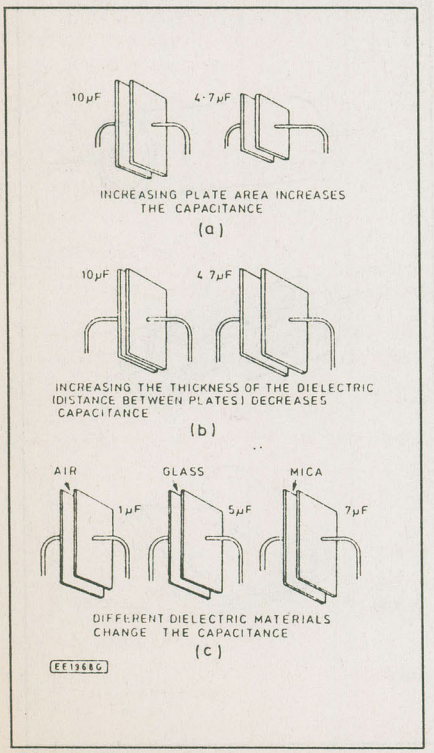


Fig. 5. Variation of capacitance with dimensions of a capacitor.

Unit of Capacitance

A capacitor holds (stores) electric charge, rather like a bucket holds water. The amount of charge it stores depends on the capacitance value (in farads) of the capacitor and the size of the voltage used to charge it. Charge (symbol Q) is a quantity of electricity, the elementary particles of which are protons and electrons. Since the charge on an electron (or proton) is very small, charge is measured in *coulombs* (symbol C); one coulomb is equal to 6.29×10^{18} electrons.

A capacitor is "charged" by connecting it to a voltage source, as shown in Fig. 6. The amount of charge acquired by the capacitor can be defined as follows:

A capacitor has a capacitance of one farad if a charge of one coulomb raises the potential difference by one volt.

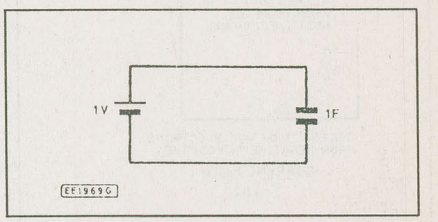


Fig. 6. Charging a capacitor.

This means that for a one farad capacitor connected to a one volt DC source, as shown in Fig. 6, the capacitor will acquire a charge of one coulomb (i.e. 6,290,000,000,000,000,000 more electrons on one plate than on the other plate). So, for any given capacitor:

Capacitance = Charge/Voltage, ie, C=Q/V

Illustrative Example

What is the charge on a 100u capacitor connected across a supply of 10V DC?

$C=Q/V$ $CV=QV/V$

$Q=CV=10 \times 100 \times 10^{-6}$

$=1000 \times 10^{-6}=1 \times 10^{-3}$

Therefore Charge (Q)=1mC (one milli-coulomb)

Capacitors in Parallel

Total capacitance in a circuit containing capacitors in parallel is the sum of all the individual capacitors:

$$C_t=C_1+C_3...+C_n$$

This is easy to understand because

No other training—in school, on the job, anywhere—shows you how to troubleshoot and service computers like NRI

DIGITAL MULTIMETER
Professional test instrument for quick and easy measurements.

HARD DISK
20 megabyte hard disk drive you install internally for greater data storage capacity and data access speed.

***NEW!* AT-COMPATIBLE COMPUTER**
High-speed 80286 CPU (12 MHz clock, 0 wait states), 1 meg RAM, 1.2 meg, 5¼" high-density floppy disk drive.

MONITOR
High-resolution, non-glare, 12" TTL monochrome monitor with tilt and swivel base.

LESSONS
Clearcut, illustrated texts build your understanding of computers step by step.

TECHNICAL MANUALS
With professional programs and complete specs on your computer.

DIGITAL LOGIC PROBE
Simplifies analyzing digital circuit operation.

SOFTWARE
Including MS-DOS, GW BASIC, word processing, database and spreadsheet programs.

DISCOVERY LAB
Complete breadboarding system to let you design and modify circuits, diagnose and repair faults.

Only NRI walks you through the step-by-step assembly of a powerful AT-compatible computer system you keep—giving you the hands-on experience you need to work with, troubleshoot, and service all of today's most widely used computer systems. You get all it takes to start a money-making career, even a business of your own in computer service.

No doubt about it: The best way to learn to service computers is to actually *build* a state-of-the-art computer from the keyboard on up. As you put the machine together, performing key tests and demonstrations at each stage of assembly, you see for yourself how each part of it works, what can go wrong, and how you can fix it.

Only NRI—the leader in career-building, at-home electronics training for more than 75 years—gives you such practical, real-world computer servicing experience. Indeed, no other training—in school, on the job, *anywhere*— shows you how to troubleshoot and service computers like NRI.

You get in-demand computer servicing skills as you train with your own AT-compatible system—now with 20 meg hard drive

With NRI's exclusive hands-on training, you actually build and keep the powerful new AT-compatible West Coast 1010 ES computer, complete with 1 meg RAM and 20 meg hard disk drive.

You start by assembling and testing the 101-key "intelligent" keyboard, move on to test the circuitry on the main logic board, install the power supply and 1.2 meg 5¼" floppy disk drive, then interface your high-resolution monitor. But that's not all.

Only NRI gives you a top-rated micro with complete training built into the assembly process

Your NRI hands-on training continues as you install the powerful 20 megabyte hard disk drive—today's most wanted computer peripheral—included in your course to dramatically increase your computer's storage capacity while giving you lightning-quick data access.

Having fully assembled your West Coast 1010 ES, you take it through a complete series of diagnostic tests, mastering professional computer servicing techniques as you take command of the full power of your computer's high-speed 80286 microprocessor.

In no time at all, you have the confidence and the know-how to work with, troubleshoot, and service every computer on the market today. Indeed you have what it takes to step into a full-time, money-making career as an industry technician, even start a computer service business of your own.

No experience needed, NRI builds it in

You need no previous experience in computers or electronics to succeed with NRI. You start with the basics, following easy-to-read instructions and diagrams, quickly moving from the fundamentals to sophisticated computer servicing techniques. Step by easy step, you get the kind of practical hands-on experience that makes you uniquely prepared to take advantage of every opportunity in today's top-growth field of computer service.

What's more—you learn at your own pace in your own home. No classroom pressures, no night school, no need to quit your present job until you're ready to make your move. And all throughout your training, you have the full support of your personal NRI instructor and the NRI technical staff always ready to answer your questions and give you help whenever you need it.

Your FREE NRI catalog tells more

Send today for your free full-color catalog describing every aspect of NRI's innovative computer training, as well as hands-on training in robotics, video/ audio servicing, electronic music technology, security electronics, telecommunications, and other growing high-tech career fields.

If the coupon is missing, write to NRI School of Electronics, McGraw-Hill Continuing Education Center, 330 Progress Avenue, Scarborough, Ontario M1P 2Z5.

AT is a registered trademark of International Business Machines Corporation

NRI School of Electronics

McGraw-Hill Continuing Education Center
330 Progress Avenue, Scarborough, Ontario M1P 2Z5.

☑ **Check one FREE catalog only**

- ☐ **Computers and Microprocessors**
- ☐ Robotics
- ☐ TV/Video/Audio Servicing
- ☐ Computer Programming
- ☐ Security Electronics
- ☐ Electronic Music Technology
- ☐ Basic Electronics
- ☐ Telecommunications

Name (please print) Age

Address ( ) Telephone

City/Prov./Code

Member of Private Career Education Council 11-040

Capicitors and Capacitance

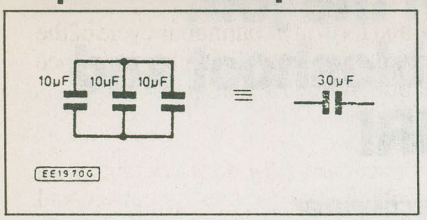


Fig. 7. Capacitors in parallel.

adding capacitors is the same as increasing the plate area and, as we have just seen, an increase in plate area increases the value of the capacitor. Fig. 7 demonstrates that adding three 10u capacitors connected in parallel produces an equivalent 30u capacitance.

Care should be taken, when increasing a particular value of capacitance by connecting capacitors in parallel, not to reduce the working voltage of the combination below the required value. The working voltage of the combination will be the rating of the capacitor having the lowest working voltage; for example, a 47u capacitor with a working voltage of 6.3 volts and a 10u capacitor with a working voltage of 100 volts connected in parallel have a maximum working voltage of 6.3 volts for the combination.

Capacitors in Series

Connecting capacitors in *series* reduces the total capacitance in the same way that connecting resistors in *parallel* reduces

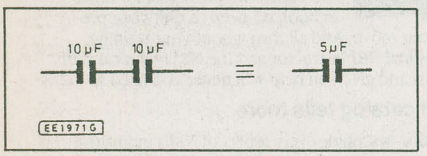


Fig. 8. Capacitors in series.

the total resistance (Fig. 8). So the formula for calculating the equivalent capacitance of series capacitors is similar to the formula for finding the equivalent resistance of parallel resistors:

$$C_t = 1/(1/C_1 + 1/C_2 ...\text{etc})$$

The expression can be simplified by using the "product over the sum" process when there are only two capacitors:

$$C_t = (C_1 \times C_2)/(C_1 + C_2)$$

The maximum working voltage for a combination of series connected capacitors will be greater than any one of the voltage ratings of the individual capacitors; for example, for a couple of 10u capacitors each with a 10 volt working voltage rating (connected in series to make an equivalent 5u capacitor), the equivalent safe working voltage for the combination will be 20 volts.

Capacitors and DC

When a capacitor is first connected to a DC power supply, current flows in the circuit until the capacitor is fully charged (it is fully charged when the voltage across the plates is equal to the supply voltage) and then current stops. The fact that current flows at all may be a bit of a surprise; after all, the capacitor sits in the circuit rather like an open switch, particularly if the

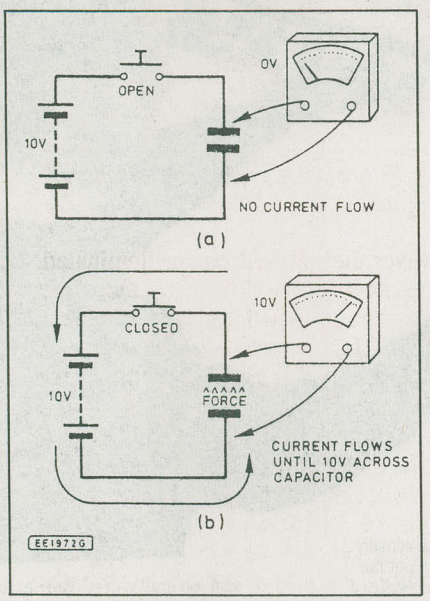


Fig. 9. Voltage across a capacitor.

dielectric of the capacitor is air.

Actually, open switch contacts do act like a capacitor but the distance between the contacts is so great (remember — the closer the capacitor plates are to each other, the greater the capacitance) the capacitance is negligible.

Consider the diagram of Fig. 9a. While the switch is open there is no voltage across the plates of the capacitor. When the switch is closed current flows, rapidly at first, in the direction of the arrows shown in Fig. 9b; current continues to flow, but diminishing all the time, until the capacitor is charged to the same level as the battery when current stops. How long it takes for the capacitor to charge is a period of time which is determined by the value of the capacitor and the resistance in the circuit (in this case, the resistance of the battery, connecting wires and component leads); we will come to this a little later.

Current flows because electrons from the top capacitor plate are attracted to the positive terminal of the battery (unlike charges attract), pushed towards the negative terminal inside the battery (by electromotive force), and repelled from the negative terminal to the bottom plate of the capacitor (like charges repel). An excess of electrons then exists on the bottom plate, giving a potential difference equal to the supply voltage across the two plates as the current ceases to flow.

The electrons belonging to the top capacitor plate are now on the bottom plate and they cannot return whence they came because of the insulating properties of the dielectric. An electrostatic field with a force equal to the supply voltage is now acting inside the capacitor; Fig. 10 shows how the unlike charges of the protons and electrons from the two plates line up in the electrostatic field, attempting to move together to equalize the charges. This force field remains even when the switch is opened or the capacitor is removed from the circuit; hence the capacitor is referred to as a storage device.

The capacitor can be discharged by

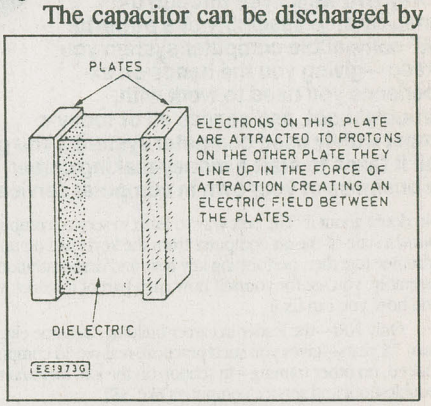


Fig. 10. Electrons in a charged capacitor.

providing a conductive path between the two plates, as shown in Fig. 11, allowing the excess electrons to bypass the dielectric and return to the plate from which they originally came. Fig. 12 shows a s.p.d.t. switch configured to charge the capacitor, through a resistor, in one position and discharge it, again through the resistor, in the other position.

In this circuit the capacitor charges or discharges, depending on the switch position, through the same resistance — the value of R — (the resistance in the battery and the wires is so small it can be ignored) so the time taken for both charge and discharge is the same.

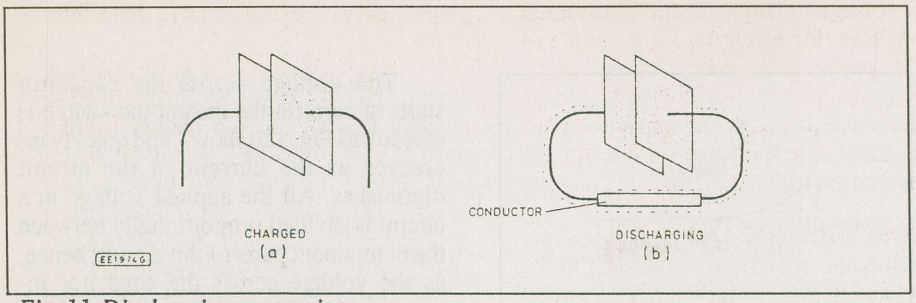


Fig. 11. Discharging a capacitor.

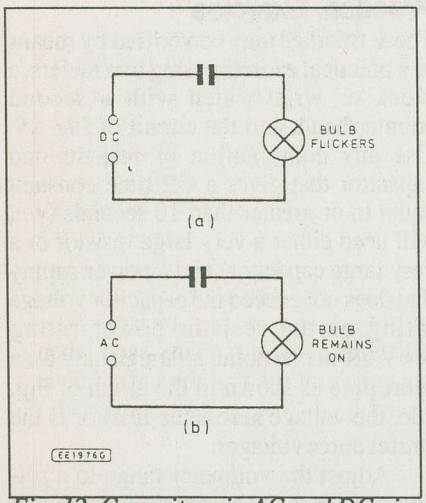


Fig. 12. Capacitors in AC and DC circuits.

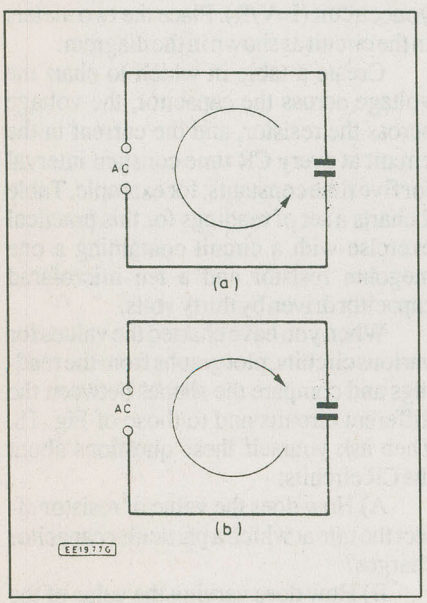


Fig. 14. Electrons in an AC circuit.

Capacitors and AC

When a DC voltage is applied to the circuit of Fig. 13a, the bulb just flickers as a result of the transient current. When an AC voltage is applied to the same circuit (Fig. 13b), however, the bulb will remain illuminated. Alternating current flows continuously in an AC circuit. It is important to realize, though, that current does *not* flow *through* the capacitor — it cannot because of the dielectric between the plates.

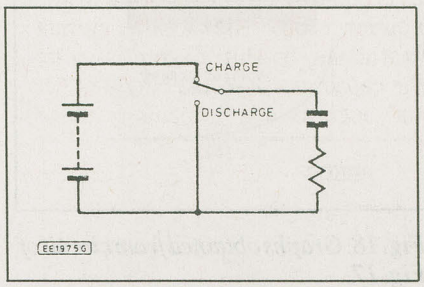


Fig. 12. Circuit to charge and discharge a capacitor.

In fact, as illustrated in Fig. 14, current flows into the capacitor (to charge it — electrons accumulate on one plate) during one half cycle and out of the capacitor (to discharge it in the opposite direction, (electrons accumulate on the other plate) during the other half cycle. It does this repeatedly for as long as the AC supply is present.

The capacitor is first charged positively and then discharged to zero volts, then it is charged negatively followed by being discharged back to zero again. So, as Fig. 14 shows, electrons repeatedly flow back and forth in a continuous cycle of the capacitor trying to first charge in one direction and then in the other.

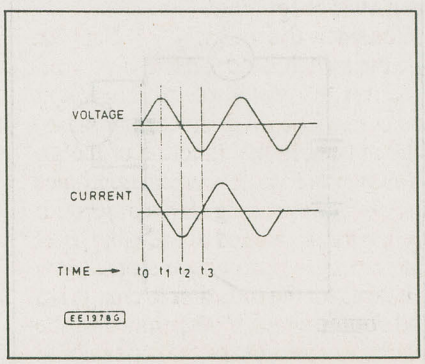


Fig. 15. Voltage and current in Fig. 14 circuit.

Phase

But the current flow does not change in step with the voltage (we say current and voltage are out of phase in a capacitor circuit), as illustrated in the graph of Fig. 15. At the instant AC is applied, the voltage starts to rise in the positive direction. As the supply voltage increases, the capacitor charges, the voltage across it gets closer to the supply voltage and current decreases accordingly. At time t_1 the capacitor is charged to the maximum value and current is zero.

As the supply voltage decrease the capacitor discharges and, at time t_2, the power supply voltage is zero and current has taken a maximum negative value. The current continues to flow but diminishes as the voltage builds up in the negative direction. When the supply voltage has reached its maximum in the negative direction (at t_3) the capacitor has again become fully charged and current has dropped to zero. It can be seen from the graph that current is a quarter of a cycle (90°) ahead of the supply voltage.

CR Time Constant

The time taken for capacitors to either charge or discharge through a resistance is measured in terms of *capacitance-resistance time constants* (usually abbreviated to CR time constants). The CR time constant is the time taken to charge any value capacitor to a voltage equal to 63.2 percent of the final fully charged voltage or discharge a capacitor to 36.8 percent of the original fully charged voltage. The time constant (T) of a CR circuit is: $T = C \times R$.

A capacitor charges to 63.2 percent of its final value in one CR time constant so, for example, a 10u capacitor charged through a 10k resistor from a 10 volt source would have 6.32 volts ((63.2 x 10)/100=6.32) across its plates 100 milliseconds ($10^{-5} \times 10^{4} = 10^{-1} = 0.1$ sec=100ms) after power was applied to the circuit. For the same CR circuit, the same time constant (100ms) applies for discharging the capacitor of 3.68 volts. Capacitor charge and discharge times are shown graphically, in terms of CR time constants and voltage, in Fig. 16.

It can be seen from these graphs that it takes about five CR time constants to completely charge or discharge a capacitor; we have to decide on a voltage very close to the supply because theoretically, as

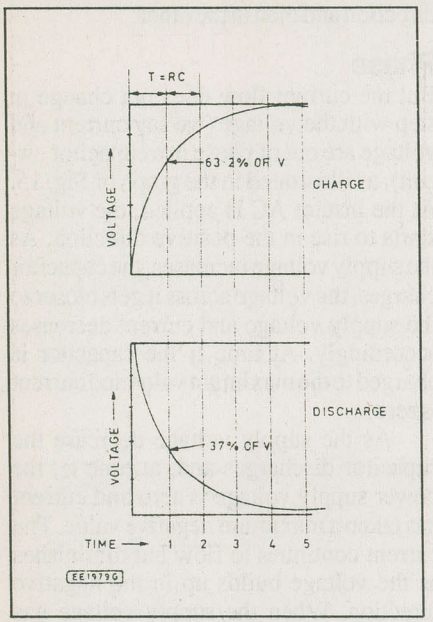


Fig. 16. RC charge and discharge graphs.

shown by the graphs, the capacitor never quite completes the charging or discharging process. We say, as a rule of thumb, that it takes five CR time constants to complete the process.

The subject of the time constant equation can be changed to determine the value of either the resistor or capacitor for the required time constant:

$R = T/C$ and $C = T/R$

Illustrative Example

What capacitor must be used with a 500 ohm resistor for a 50ms time constant?

$C = T/R = 0.1 \times 10^{-3}$ or 100u.

What resistor must be used with a 10n capacitor for 100us time constant?

$R = T/C = 10 \times 10^{3}$ or 10k.

We have looked, above, at how the capacitor works with respect to current flow in the process of storing a charge, and at the charge and discharge of capacitors in time constants. Now let us look a little closer at what happens with respect to current and voltage in a CR circuit. Fig. 17 shows a capacitor and resistor connected in series across a battery supply via an SPST. switch. The capacitor is initially uncharged with zero volts across its plates.

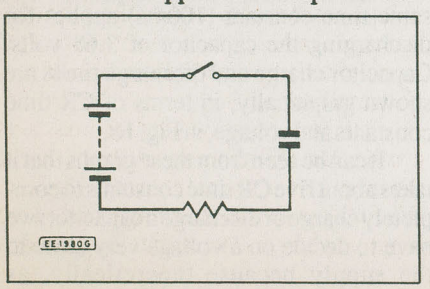


Fig. 17. Simple test circuit.

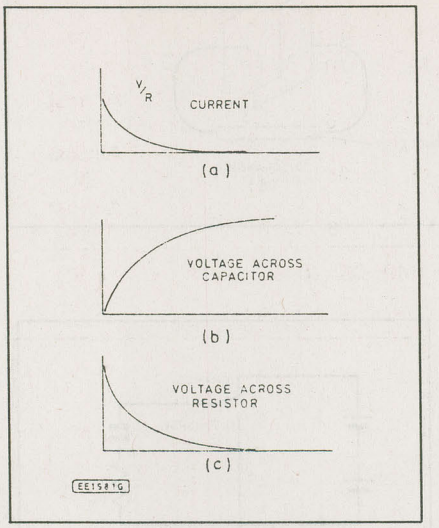


Fig. 18. Graphs obtained from circuit of Fig. 17.

If we measured the voltage across the resistor and the current through it, and the voltage across the capacitor at regular intervals throughout the time that the transient current flows (i.e. the time it takes for the capacitor to charge up), the whole picture may be represented by the three graphs of Fig. 18. Current would vary throughout the transient period as shown in Fig. 18a: at the instant the switch is closed the current will be at its maximum value (V/R) and then fall quickly over the period to zero as the capacitor becomes charged.

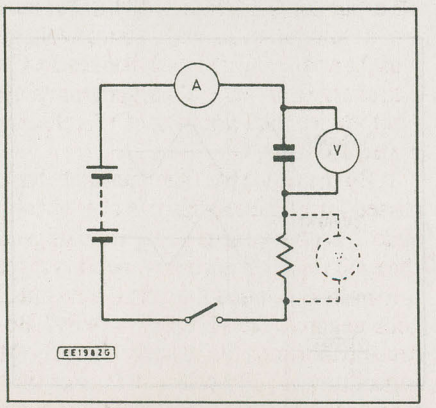


Fig. 19. Circuit for the practical exercise.

The voltage across the capacitor starts at zero (at the instant the switch is closed), as Fig. 18b shows, and quickly increases as the current in the circuit diminishes. All the applied voltage in a circuit is divided proportionally between the component parts of the circuit; hence, as the voltage across the capacitor increases, the voltage across the resistor falls, as shown in Fig. 18c.

Practical Exercise

These findings may be verified by means of a practical exercise using two meters, a clock or wrist-watch with a second counter/hand, and the circuit of Fig. 19. Use any combination of resistor and capacitor that gives a CR time constant equal to or greater than 10 seconds (you will need either a very large resistor or a very large capacitor) and a power supply that does not exceed the capacitor voltage rating or the resistor power rating ($P = V^2/R$-at one point, although only for a short time as shown in the graph of Fig. 18c, the voltage across the resistor is the entire source voltage).

Adjust the voltmeter range to a setting greater than the supply voltage and the ammeter to a setting greater than the supply voltage divided by the resistor in your circuit ($I = V/R$). Place the two meters in the circuit as shown in the diagram.

Create a table in which to chart the voltage across the capacitor, the voltage across the resistor, and the current in the circuit at every CR time constant interval for five time constants; for example, Table 2 charts a set of readings for this practical exercise with a circuit containing a one megohm resistor and a ten microfarad capacitor driven by thirty volts.

When you have charted the values for various circuits, plot graphs from the readings and compare the shapes between the different circuits and to those of Fig. 18. Then ask yourself these questions about the CR circuits:

A) How does the value of resistor affect the rate at which a particular capacitor charges?

B) How does varying the value of the capacitor affect the rate at which it charges when the resistor value is constant?

C) What percentage of the total supply voltage is dropped across the capacitor in the first CR time constant?

D) What percentage of the total supply voltage is dropped across the resistor in the first CR time constant?

E) What is the relationship between the voltage dropped across the capacitor

	CR TIME CONSTANTS					
		1st	2nd	3rd	4th	5th
Time (seconds)	0	10	20	30	40	50
Current (microamps)	30	11	6	2	1	Almost zero
Voltage across capacitor	0	19	26	28	29	Almost 30
Voltage across resistor	30	11	6	2	1	Almost zero

V=30V: C=10μF: R=1MΩ: CR=10 sec:

Table 2.

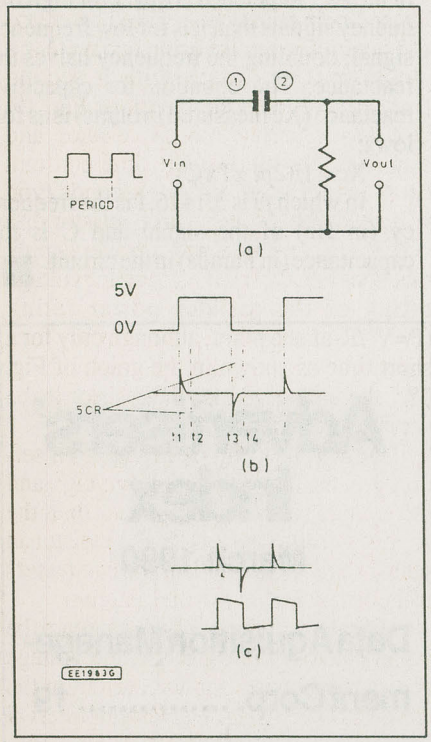


Fig. 20. Response of the circuit to a square wave.

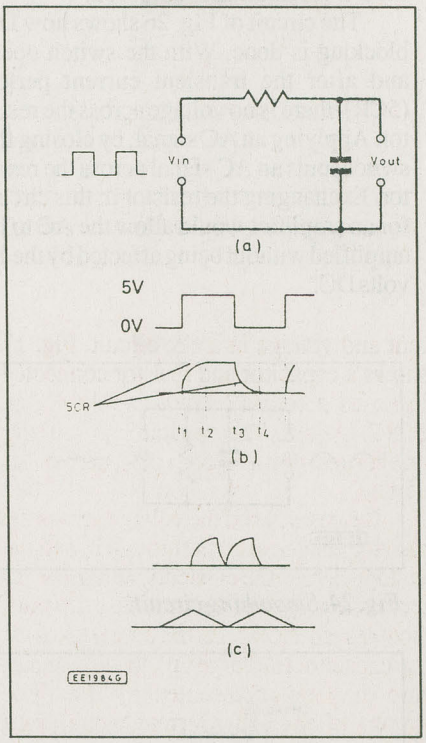


Fig. 21. Response of the circuit to ta square wave.

and the voltage dropped across the resistor?

F) What happens to current in the circuit when the voltage across the capacitor is at a maximum?

G) What happens to current in the circuit when the voltage across the resistor is at a maximum?

CR Response to Digital Signals

Now that we have the concept of the CR time constant under our belts, we can look at the transient response of CR circuits to signals which are more likely to appear in digital circuits. We will analyze the response of the circuits in Fig. 20 and 21 to the input of a square wave.

Applying a square wave to the input of the circuit (a) in Fig. 20 produces an output looking like the graph in (b). When the input goes to +5 volts at time t_1, plate 2 of the capacitor also goes to +5 volts (current is at its maximum so all the source voltage must be across the resistor): it takes 5 x C x R to charge up — in the charged state plate 1 of the capacitor would be at +5 volts and plate 2 at 0 volts.

By the time five time constants have passed (at t_2) the capacitor is charged and plate 2 becomes zero volts; it remains at zero volts until the square wave changes to zero volts at t_3 when the voltage at plate 2 goes negative (to -5 volts — why? Because at the time immediately before t_3 the capacitor was fully charged, it takes time for it to discharge so 5 volts worth of negative charge piles onto plate 2 at the instant t_3). It discharges five time constants later (t_4). And so on at each transition from 0 volts to 5 volts and back again.

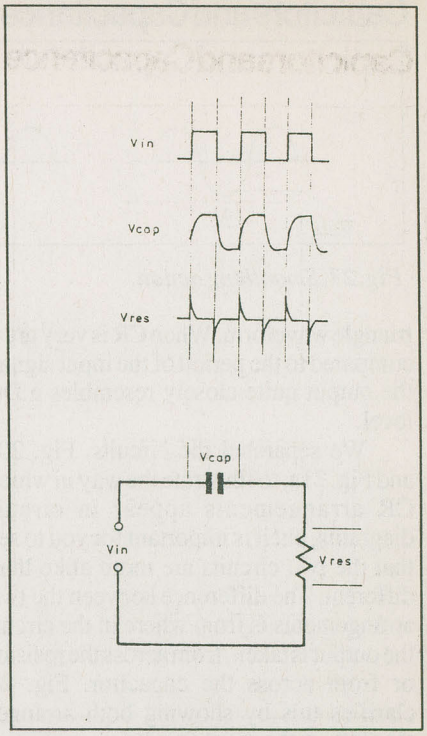


Fig. 22. Voltage graphs in a simple circuit.

The waveforms in Fig. 20c show how the value of the CR time constant compared to the period of the input waveform change the shape of the output. The shorter the CR time is, compared to the period of the input, the more spiky will be the output. For CR times much greater than the period of the input, the shape of the output closely resembles the shape of the input.

Applying the same square wave to the input of the circuit in Fig. 21 (where, compared to Fig. 20 the positions of the resistor and capacitor have been reversed) produces an output looking like that in (b) of the same figure. At time t_1 the capacitor starts to charge through the resistor, taking five time constants to reach 5 volts (at t_2). The capacitor remains charged until t_3 when the input changes from 5 volts to 0 volts; from this time it takes five time constants to discharge back to zero at t_4. And so on at each transition from 0 volts to 5 volts and back again.

The wave shapes for time constants greater than and shorter than the period of the input waveform are shown in Fig. 21c. When CR is shorter than the period of the input waveform, the output is a rounded

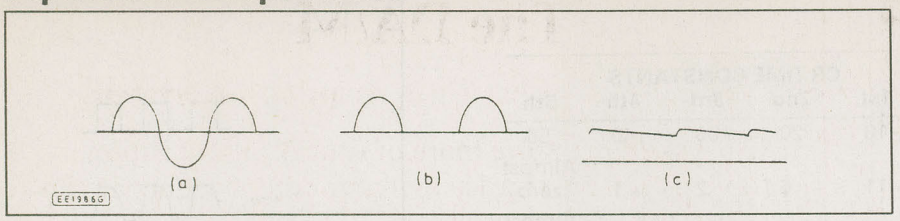


Fig. 23. Smoothing action.

triangle waveform. When CR is very great compared to the period of the input signal, the output quite closely resembles a DC level.

We separated the circuits, Fig. 20a and Fig. 21a, to illustrate the way in which CR arrangements appear in circuit diagrams, but it is important for you to see that the two circuits are more alike than different. The difference between the two arrangements is from where in the circuit the output is taken, from across the resistor or from across the capacitor. Fig. 22 clarifies this by showing both arrangements from the same circuits.

It can be seen from the foregoing examination that the ability of such circuits to change the shape of the signal can be used to great advantage in some applications. An application of particular interest to us, in this course, is that of "smoothing".

Smoothing

Smoothing is an application of the above ideas used in mains derived DC power supply circuits. The smoothing capacitor is used in the process of converting AC into DC. We do not go into detail here but the stages involved in a simple AC to DC conversion are outlined in Fig. 23.

First the negative half cycle of the AC signal (a) has to be removed to produce a signal like that in (b). This is a pulsating DC and not *smooth* enough for most applications. The easiest way of smoothing out the pulses is by feeding the signal into a capacitor (as shown in Fig. 24) to produce a DC output something like that in Fig. 23c. This DC voltage still fluctuates but it is acceptable for many applications.

The smoothing capacitor works by holding the charge (or only discharging a little) between one input pulse and the next, as illustrated in Fig. 25. The larger the capacitor, the longer it holds the charge and the smoother the DC signal becomes.

Blocking

Blocking is used in applications where AC and DC voltages are both present in the same circuit. An amplifier, for example, has both types of voltage and often requires just the AC signal to be amplified; the DC voltage must be *blocked*.

The circuit of Fig. 26 shows how DC blocking is done. With the switch open, and after the transient current period (5CR), there is no voltage across the resistor. Applying an AC signal, by closing the switch, puts an AC signal across the resistor. Exchanging the resistor in this circuit for an amplifier would allow the AC to be amplified without being affected by the 10 volts DC.

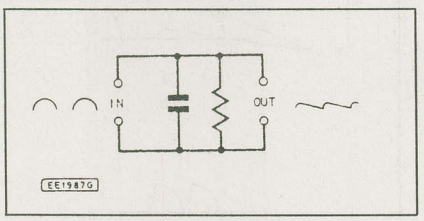


Fig. 24. Smoothing circuit.

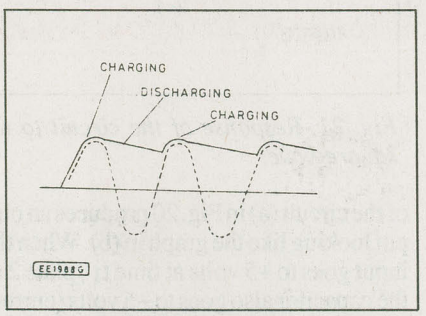


Fig. 25. Illustration of smoothing.

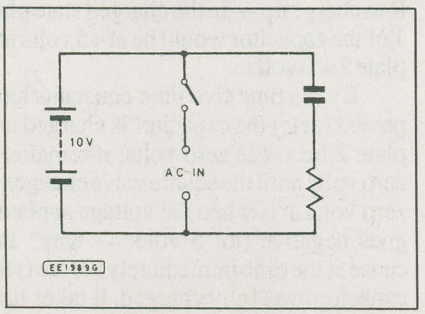


Fig. 26. Illustration for blocking.

Reactance

Before we leave the subject of capacitors and capacitance we should mention a property called *reactance*. Reactance is a sort of resistance that only affects capacitive (and inductive) AC circuits; for example, replacing the capacitor in the circuit of Fig. 13b by a wire link would cause the bulb to get brighter — this means that more current would flow so the capacitor must have a resistance to AC.

Reactance, unlike resistance, is not a constant — it changes with the frequency of the AC. Reactance is lower for high frequency signals than it is for low frequency signal; doubling the frequency halves the reactance. The equation for capacitive reactance (Xc measured in ohms) is as follows:

$Xc = 1/(2pi \times f \times C)$

In which *pi* is 3.1416, f is the frequency (in Hz) of the signal and C is the capacitance (in Farads) in the circuit. ■

Advertisers' Index

March 1990

Data Aquisition Management Corp. 19

Exceltronix 2,3

Information Unlimited 19

McGraw-Hill 13

Orion Electronics 38,39

R.H. Nichols 37

Toshiba Information Systems 4

The Pin Factory 40

Fax: 416-445-8149

AMAZING
SCIENTIFIC & ELECTRONIC PRODUCTS

PLANS (PARTS ARE IN STOCK)

GRA1 —	ANTI GRAVITY GENERATOR	$10.00
LC7 —	40 WATT BURNING CUTTING LASER	$20.00
RUB4 —	HI POWER PULSED DRILLING LASER	$20.00
BTC5 —	1 MILLION VOLT TESLA COIL	$20.00
MCP1 —	HI VELOCITY COIL GUN	$15.00
LLS1 —	LASER LIGHT SHOW 3 METHODS	$20.00
EH1 —	ELECTRONIC HYPNOTISM TECHNIQUES	$8.00
EML1 —	LOWER POWERED COIL GUN LAUNCHER	$8.00
JL3 —	JACOB LADDER 3 MODELS	$10.00
SD5 —	SEE IN THE DARK	$10.00
LEV1 —	LEVITATION DEVICE	$10.00

KITS (ASSISTANCE PROGRAM AVAILABLE)

FMV1K —	3 MILE FM VOICE TRANSMITTER	$34.50
PFS1K —	HAND CONTROLLED PLASMA FIRE SABER	$49.50
NIG7K —	HI FLUX NEGATIVE ION GENERATOR	$34.50
PG5K —	PLASMA LIGHTNING GLOBE	$49.50
LHC2K —	VISIBLE SIMULATED 3 COLOR LASER	$44.50
HOD1K —	HOMING/TRACKING BEEPER TRANSMITTER	$44.50
LGU5K —	2.5 MW HAND-HELD VISIBLE LASER GUN	$249.50
BTC3K —	250,000 VOLT TABLE TOP TESLA COIL	$249.50
IOG2K —	ION RAY GUN, project energy without wires	$129.95
TKE1K —	TELEKINETIC ENHANCER/ELECTRIC MAN	$79.50
VWPM7K —	3 MILE AUTO TELEPHONE TRANSMITTER	$49.50

ASSEMBLED

ASSEMBLED IN OUR LABS

LIST10 —	INFINITY XMTR Listen in via phone lines	$169.50
IPG70 —	INVISIBLE PAIN FIELD BLAST WAVE GENERATOR	$74.50
ITM10 —	100,000 VOLT INTIMIDATOR UP TO 20'	$99.50
TAT30 —	AUTOMATIC TELEPHONE RECORDING DEVICE	$24.50
PSP40 —	PHASOR SONIC BLAST WAVE PISTOL	$89.50
DNE10 —	ALL NEW 26" VIVID COLORED NEON STICK	$74.50
LGU20 —	.5 TO 1MW VISIBLE RED HeNe LASER GUN	$199.50
BLS10 —	100.00 WATT BLASTER DEFENSE WAND	$89.50

EASY ORDERING PROCEDURE - TOLL FREE 1-800-221-1705
or 24 HRS ON 1-603-673-4730 or FAX IT TO 1-603-672-5406
VISA, MC, CHECK, MO IN US FUNDS. INCLUDE 10% SHIPPING. ORDERS $100.00 & UP ONLY ADD $10.00. CATALOG $1.00 OR FREE WITH ORDER.

INFORMATION UNLIMITED
P.O. BOX 716, DEPT. ET1 AMHERST, NH 03031

Circle No. 10 on Reader Service Card

The DA/M™

The Lowest Cost Data Acquisition System

Our DA/M can solve more of your data acquisition problems at a lower price than any other product on the market. DA/M's are used for:

- Military meteorological stations.
- Building management.
- Automated hydroponic farming.
- Industrial process control.
- Your application

In fact, DA/M's can be used whenever you can't afford to use any one else's product.

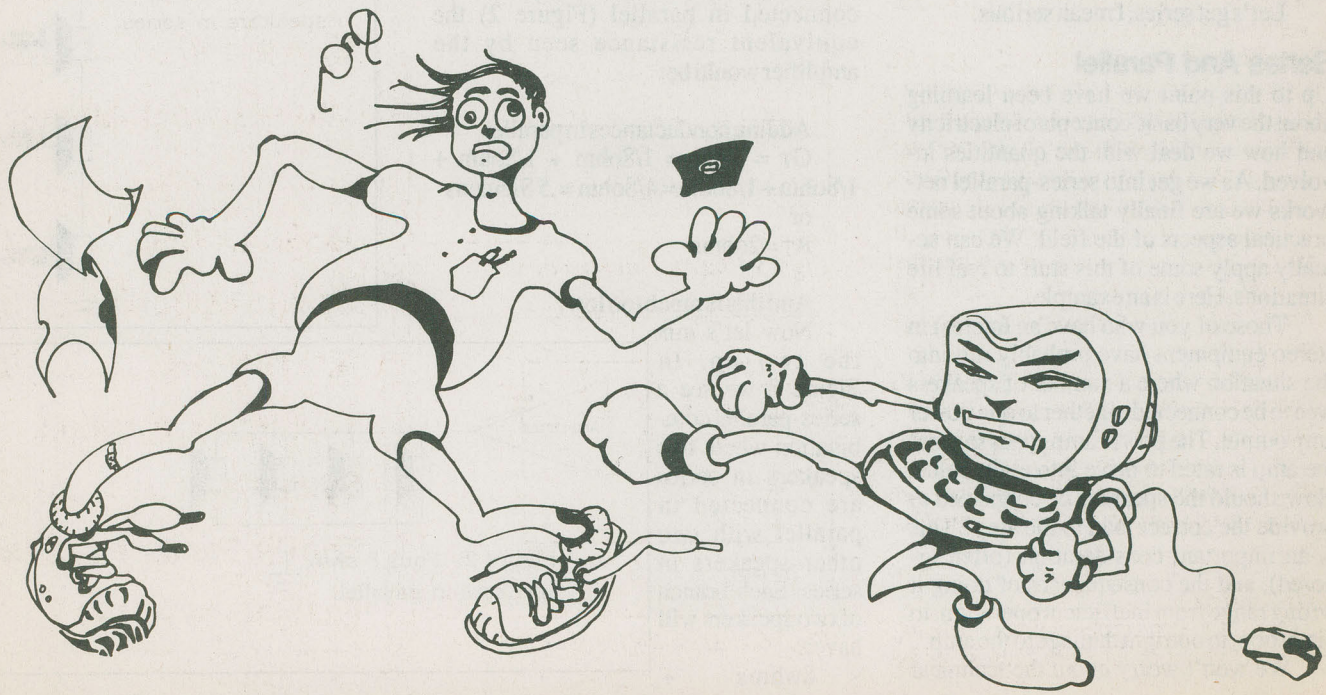
Made in North America, DA/Ms are available NOW!

DA/M
DATA ACQUISITION AND MANAGEMENT CORPORATION LTD.
#140, 17303 - 102 Avenue
Edmonton, Alberta, Canada T5S 1J8

Phone 1-403-486-3534
Fax 1-403-486-3535

Circle No. 11 on Reader Service Card

BITS & BYTES



COMPUTER BOOTS BACK !

FEATURE

Basic Electricity Part 3

In which we examine series and parallel circuits.

Ron C. Johnson

Well, here we are again in this land of great potential, charging upwards, full power. Though significant currents continue to oppose our forces I remain steadfast in my resistance to their rise. In fact, I charge you...

Sorry. Just practising my speech for the Electronics Club elections, next week.

Where were we?

Ah, yes! Last month we learned about Scientific Notation, Engineering Units, and the resistor color code before we looked at series and parallel together as well as looking at some practical aspects of meters, how they work and how to use them.

Let's get series, I mean serious.

Series And Parallel

Up to this point we have been learning about the very basic concepts of electricity and how we deal with the quantities involved. As we get into series-parallel networks we are finally talking about some practical aspects of the field. We can actually apply some of this stuff to real life situations. Here is an example.

Those of you who have an interest in stereo equipment have probably run into the situation where a number of speakers wee to be connected together to one power amp output. The power amp specs say that the amp is rated to drive into eight ohms. How should the speakers be connected to provide the correct load to the amp? This is an important consideration (often ignored), and the consequences of doing it wrong range from inefficient operation, to distortion, to outright damage to the amp.

We won't worry about the technical reasons why it is so critical to keep the load resistance close to the specified value. But our job is to make sure it is done.

Let's assume that the available speakers are all eight ohms and that we have four of them to connect. Obviously, one of them connected to the amp by itself would be easy. To connect four is a little more complex. Connected all in series, (Figure 1), they would be additive as we saw in last month's segment. The total resistance would be:

8ohms + 8ohms + 8ohms + 8ohms = 32ohms

This is obviously too much.

On the other hand, if they were all connected in parallel (Figure 2) the equivalent resistance seen by the amplifier would be:

Adding conductances in parallel

$G_T = 1/R_T = 1/8ohm + 1/8ohm + 1/8ohm + 1/8ohm = 4/8ohm = .5$ Siemens

or

$R_T = 2ohms$

And this is much too low.

Now let's mix the two up. In Figure 3 we see a series-parallel combination where two speakers in series are connected in parallel with two other speakers in series. Each branch of two speakers will have:

8ohms + 8ohms = 16ohms

If we redraw the diagram substituting the equivalent 16ohm resistances we now have them in parallel. (Figure 4). Combining them we get:

Again adding conductances

$G_T = 1/R_T = 1/16ohms + 1/16ohms = .125$ Siemens

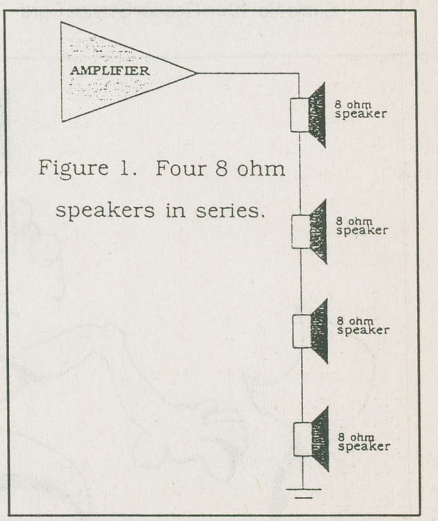


Figure 1. Four 8 ohm speakers in series.

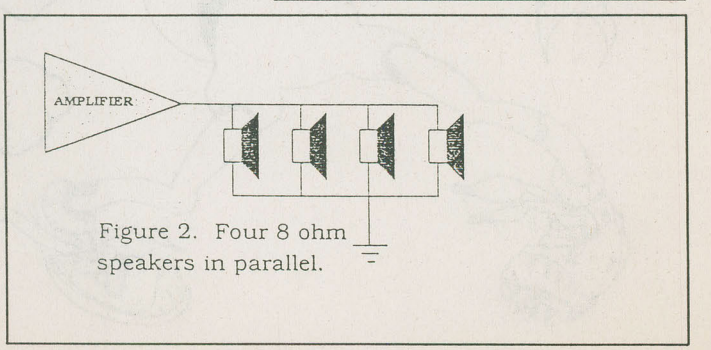
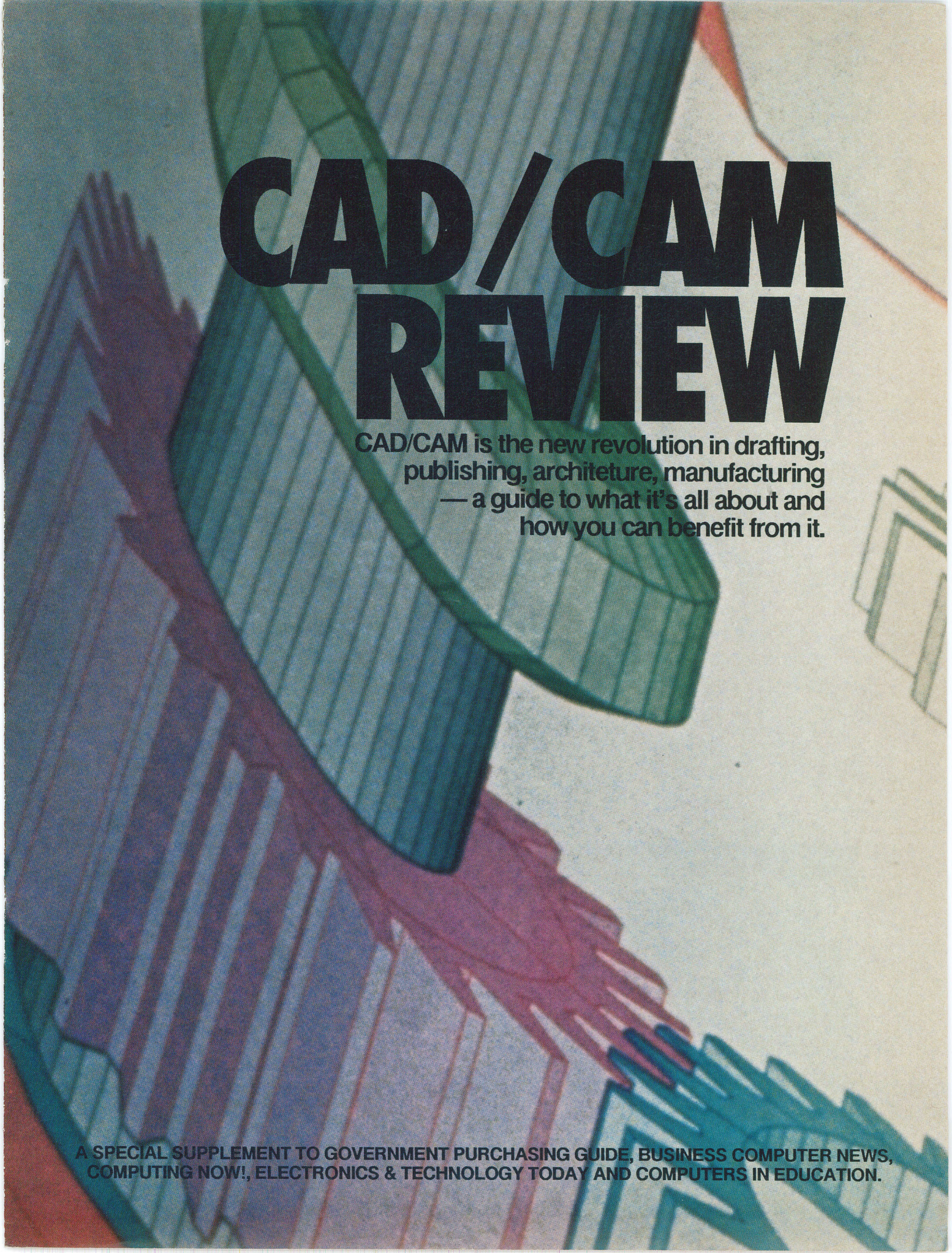


Figure 2. Four 8 ohm speakers in parallel.



CAD/CAM REVIEW

CAD/CAM is the new revolution in drafting, publishing, architeture, manufacturing — a guide to what it's all about and how you can benefit from it.

A SPECIAL SUPPLEMENT TO GOVERNMENT PURCHASING GUIDE, BUSINESS COMPUTER NEWS, COMPUTING NOW!, ELECTRONICS & TECHNOLOGY TODAY AND COMPUTERS IN EDUCATION.

DELL SYSTEM 325

- Its Intel 80386 microprocessor operates at 25 MHz allowing it to process information up to 20% faster than 20 MHz 80386-based systems.
- The system's cache memory controller, with a 32KB buffer for zero-wait-state cache access, speeds memory throughput.
- It also offers a choice of 1 MB, 2 MB or 4 MB of 32-bit RAM, configurations expandable to 16 MB.
- The advanced page mode interleaved memory architecture lets you access RAM quickly and easily.
- The system 325 supports either the optional 25 MHz Intel 80387 or WEITEK 3167 math coprocessor.
- Mass storage is a hefty 322 MB disk drive, or we can configure it with a 40, 100 or 150 MB drive.
- A 5.25" 1.2 MB diskette drive or a 3.5" 1.44 MB diskette drive is standard with the system 325, so you can select your own media type.
- System 325's 100% compatibility with MS-DOS; MS OS/2 and our own Dell UNIX System V provides unmatched systems software flexibility. Dell UNIX System V is compatible with AT&T's System V Interface Definition and will run most XENIX applications.
- Optional Dell Graphics Performance series includes either 16" or 19" high performance non-interlaced monitors coupled with a TI 34010 based graphics card.

NUTRITIONAL INFORMATION FOR THE POWER HUNGRY.

We've just shown you a sampling of what the Dell System 325 can do. But you have to call for the full menu.

As PC Magazine Editor's Choice award, it ate up the competition. Even the Compaq 386-25. It was also voted computer of the year by CHIPS.

But what really makes the Dell System 325 appetizing is our service. We're very particular about that. Unlike other computer companies, you deal directly with the people who make the system. And, it comes with a 30-day money back guarantee as well as one year on-site service.

So call now. And put the Dell System 325 on your table. You shouldn't have any reservations.

Please send me more information on the Dell System 325. Call us now or fill in this coupon and return to: Dell Computer Corporation, The Dell Building, 2 East Beaver Creek Road, Richmond Hill, Ontario L4B 2N3.

Name_____

Company_____

Address_____

Postal Code_____

Telephone_____

AD CODE NO.: BBDCO

DELL COMPUTER CORPORATION

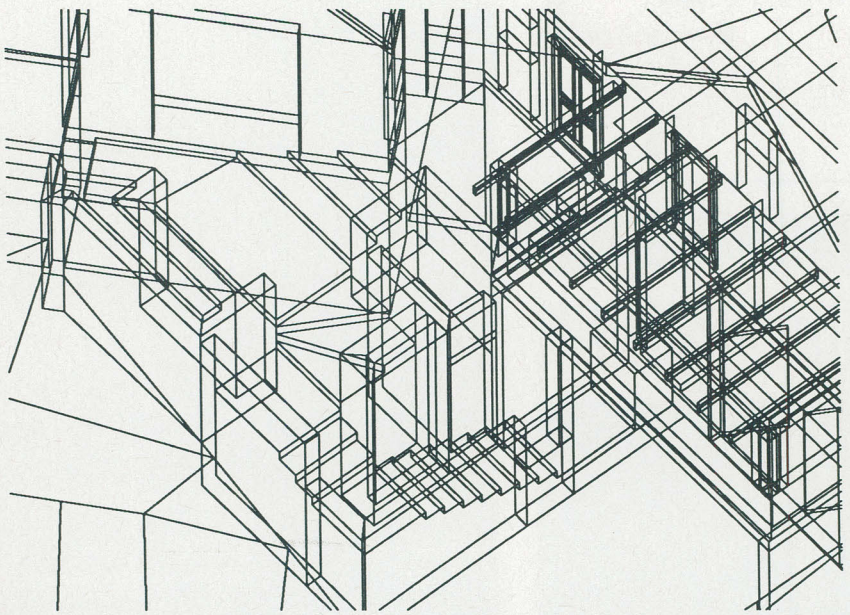
CALL 1-800-387-5752 TO ORDER.

circle no. 80 on reader service card

A Free Speed Upgrade for AutoCAD

High speed and higher resolution increase productivity

Bill Markwick



Regular AutoCAD users will agree that using this particular software for design work involves a love/hate relationship. AutoCAD is popular because of its flexibility and drawing muscle. On the other hand, what's annoying to most users, old and newalike, is the time that's wasted waiting for the drawing to berestored after a REGEN caused by a some ZOOM options. There areways around these and other AutoCAD quirks that cost a far cryless than a new 33 Mhz 386 beast. Let's examine a few.

Improving ZOOM and PAN Speed

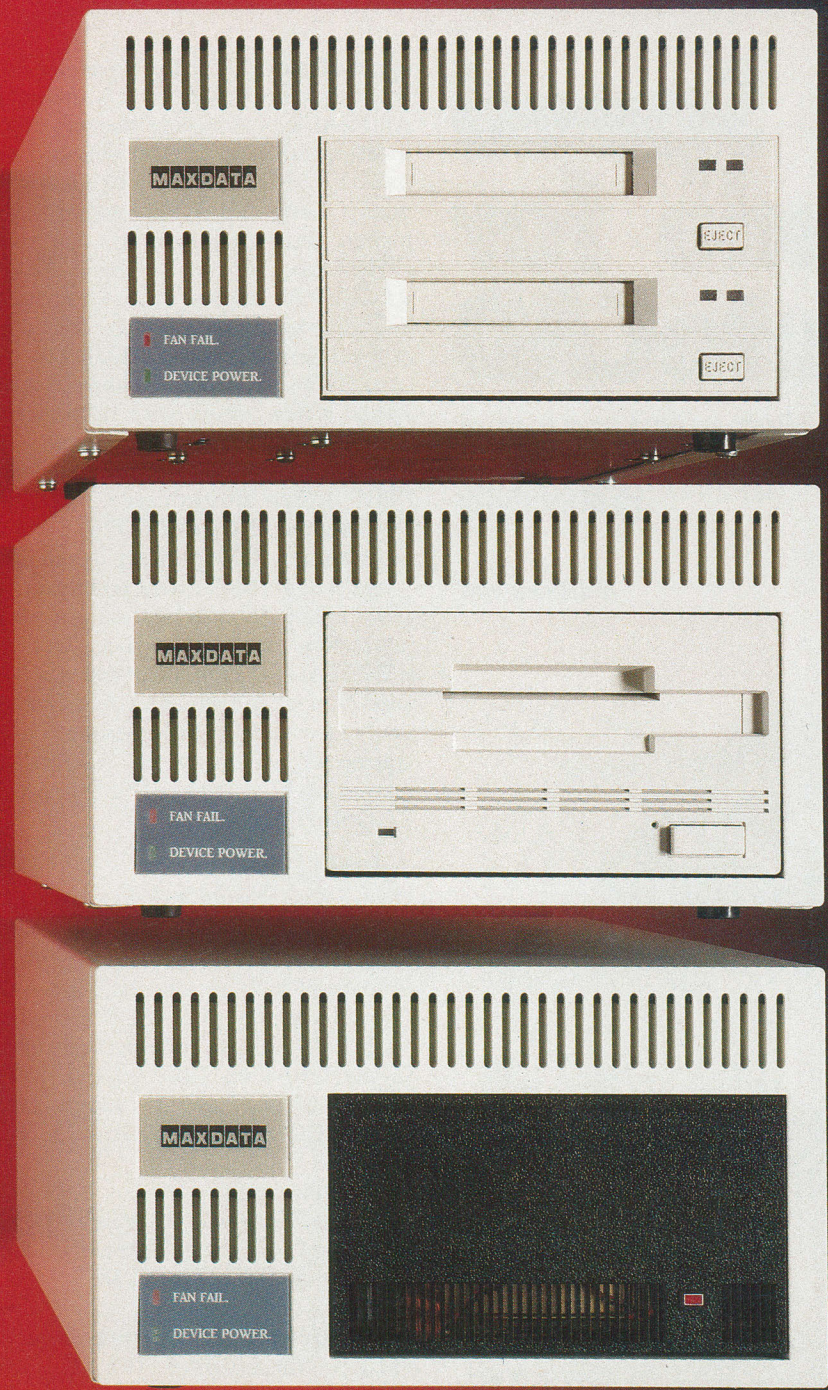
ZOOM allows one to vary the size of AutoCAD's viewing window, which directly results in the size of image you see on the screen. PAN lets you move over and see what is just off your current viewing area while keeping the same magnification factor. When one of these commands are used, AutoCAD refreshes the screen image in one of two ways, via the REDRAW or REGEN command. During a REGEN AutoCAD recalculates every vector point (start and end points of lines, arcs, etc.) in real numbers. A REDRAW, on the other hand, calculates only the integer portion of the vector, resulting in a much faster screen image being generated. A REDRAW is about five to six times the speed of a REGEN (on average). It should be obvious that in most cases a REDRAW is the preferred screen refresh method as opposed to a REGEN. Let's examine a few ways to keep REGENs to a minimum. AutoCAD has a built-in command to help in this regard. The ZOOM command with the DYNAMIC option (we're assuming you're using AutoCAD version 2.5 or higher) shows that area you can safely ZOOM into without forcing a dreaded REGEN. As long as there is no small hourglass symbol in the lower left corner of your screen, only a REDRAW will occur. Note that AutoCAD makes use of a virtual screen which has a resolution of 32,000 x 32,000 integer points. The ZOOM options PREVIOUS and WINDOW do not always cause a REGEN. However the ALL and EXTENTS will always cause a REGEN. Keep this in mind — we'll come back to this point later. To avoid a REGEN, it is necessary to know just when one will strike. Use the REGENAUTO command and set it to OFF. Now when a possible REGEN might occur, a warning message gives you the option of accepting the REGEN by answering Y, or answer N to try another ZOOM or PAN option.

A Little LISP

Get by with (a little help from) AutoLISP. There's a hit single in that subheading somewhere. No? Okay, back to work. A little AutoLISP can help speed things up. Fire up your favorite ASCII text editor (even EDLIN if you're desperate) and key in the following LISP routine called ZE.LSP (if you haven't guessed, ZE is short for ZOOM EXTENTS):

```
(defun c:ze ()
(setq PTL (getvar "extmin"))
(setq PTU (getvar "extmax")) (command "zoom" "w" PTL PTU))
```

Make sure that you include all quotes and parenthesis. Save ZE.LSP in the ACAD directory (or whatever you've named yours). To use ZE.LSP, type the following at the AutoCAD command prompt: (load "ZE"). Then press the ENTER key. To use this simple LISP routine, just type ZE at the command prompt. What the routine does is get the values of the AutoCAD variables EXTMIN (extents minimum) and EXTMAX (extents maximum). If you use ZE in place of ZOOM with the EXTENTS option, you'll avoid most REGENs when ZOOMing out to see the entire drawing on the screen. (Remember that a ZOOM with EXTENTS forces a REGEN).



Maxdata presents Advanced Storage Solutions

Maxdata MD-1200 & MD-2600
1.3 to 2.6 Gbytes of unattended back-up

4MM DAT—most reliable and cost effective back-up solution
20 sec average random access seek time
183 Kbytes/sec transfer rate—SCSI interface
Industry standard DDS format
5.25'' desktop enclosure with cables

Maxdata MD-200R
Rewritable optical disk drive

650 Mbyte Sony rewritable disk drive
1.2 MB/sec burst transfer rate
22 ms short stroke seek time
Continuous/composite format (ISO/ANSI standards)
650 Mbyte removable cartridge high performance and reliability

Maxdata MD-150W, MD-160W, MD-1700W
WORM drives (Write Once Read Many)

5.25'' and 12'' formats
600MB to 6.4 GB capacity on a single disk
5.25'' jukebox with 10 disks available

Maxdata disk drive upgrades

70MB to 2.2GB available
ST-506, ESDI and SCSI interfaces
3.5'', 5.25'' and 8'' formats

Maxdata MD-100 CD-ROM player

MAXDATA

A GTG Company
100 Leek Crescent, Unit 9
Richmond Hill, Ontario L4B 3E6
Telephone (416) 882-0600
Fax (416) 886-2314

Host adapters and software for above products available for MS-DOS, OS/2, Macintosh, VAX/VMS, ULTRIX, SUN, UNIX, HP, Xenix, Novell Netware and other environments. Complete subsystems combining the above technologies are available in tower configurations.

Dealer enquiries are welcome.

Trademark Owners: Maxdata is a registered trademark of Maxdata Inc., GTG is a registered trademark of Goldman Technology Group, MS-DOS, OS/2 and Xenix of Microsoft Corp., Macintosh of Apple Computer, Inc., VAX/VMS & ULTRIX of Digital Equipment Corp., SUN of Sun Microsystems, Unix of AT & T, HP of Hewlett Packard, Netware of Novell, Sony of Sony Corp. All products are CSA and FCC approved.

circle no. 77 on reader service card

A Faster Coarse

When you use AutoCAD straight out of the shrinkwrap, It uses your screen's maximum resolution to display the object you are creating on screen. Assuming that you're using a VGA adaptor card (640 x 480 screen resolution) or better, your circles and ellipses look pretty much like circles and ellipses. Use the VIEWRES command, answering Y when it asks you if you desire fast ZOOMs and PANs. (Can you image anyone saying no to speed? Well, maybe on a Friday afternoon.) Next you are prompted for a value (100 is usually the default value). If you have a VGA card try a value of 50. If you have higher resolution cards, insert a lower value. The result is a significant boost in both REDRAW and REGEN speed. What happens is that when the VIEWRES value is set below 100, AutoCAD starts to draw the circles, arcs and ellipses more like polygons instead. Your circle might look coarse (like a octagon) at a lower VIEWRES setting. Don't worry — if you need to see the circle as a full circle (to check fit for example), just issue the REGEN command. Yes, even after all this effort to avoid it, sometimes you need it. On an IBM 8514/A display adaptor card (1024 x 768 resolution) a Viewres value of 10 seemed workable. You'll find what setting you like best.

The Right Point of VIEW

The VIEW command is an older AutoCAD command. Using VIEW can greatly increase the speed at which one can view specific parts of a drawing on a regular basis. For example, if you have a large floorplan to lay out and must frequently refer back to a specific quadrant of the plan, use the VIEW command to create four views, one for each quadrant. You might assign names to the views such as: V1, V2, V3 and V4. Now when you're viewing one quadrant of the building, let's say V1, and you want view V3, instead of ZOOMing out and then in again, just use the VIEW RESTORE option to see V3.

Brain vs. Braun

After seeing hundreds of AutoCAD installations, one thing that's apparent is that most users believe more in getting faster hardware than investing in a little brain power. When I first started AutoCAD in 1984, the AutoCAD platform was (don't laugh) an IBM XT. Today we have 386 and now 486 processors, screaming fast memory and quick hard disks. Let's face it: we're spoiled. You'll never get enough speed when you know there will be a faster box tomorrow. So brain power must step in to help get as much speed out of the system as possible.

Again, we call upon some of AutoCAD's often-ignored features. If you examine the LAYER command, you'll notice it has the ability to FREEZE and THAW layers. When a layer is frozen, it is not only turned off, it is ignored by AutoCAD. That means when you have to use a REGEN, whatever was on that frozen layer is not regenerated. So, the speedup methods presented here may not be as great as a new 486 beast, but you'll get more done in less time at far less than what a new 486 costs, making the boss happy and keeping you employed. Now that's not bad.

Is CAD Training Necessary?

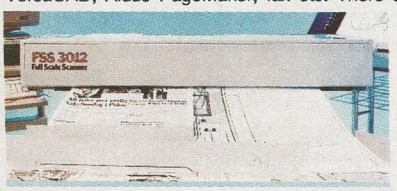
The short answer is yes

Courtney Thompson

Computer Aided Design (CAD) is becoming more common in Canadian industry. When utilized properly, it can be a versatile and powerful tool for creating and quickly editing presentation and working drawings, parts lists, illustrations for technical manuals and the like. When used to its full potential, one can really leapfrog ahead of the competition. However, when approached and applied incorrectly, CAD can become the object of company embarassment. Also, the one who brought in the ill-fated system can forget about a raise for a long while. What makes the difference between success and failure? The key is good appropriate training for all involved with the operation (directly or indirectly) of the CAD system. Let's start by looking at an (unfortunately) all-too-familiar situation of CAD misapplication. Fly-by-Nite Inc., a manufacture of aircraft lighting gear, is looking at purchasing a CAD system to help reduce the time it takes to produce shop drawings. Since no one in-house has proper knowledge about Computer Aided Design (CAD), they enlist the help of ABC CAD Dealer. The sales consultant makes hardware and software recommendations. He also offers a training schedule to help the staff learn to take best advantage of the system. Fly-by-Nite purchased a 386 based system running AutoCAD software as per ABC's advice. And the training? Fly-by-Nite thought the training unnecessary and too costly. They figured the staff would learn the system on their own. How did Fly-by-Nite make out with CAD? Nine months after introducing the CAD system to the design department to learn and utilize, there it is, in a corner collecting dust, unused. When asked for a report, the department head explained, "No one in here knows how the thing works and no one has time to learn; we have jobs to do". This situation happens all too often, but can be avoided with a little education.

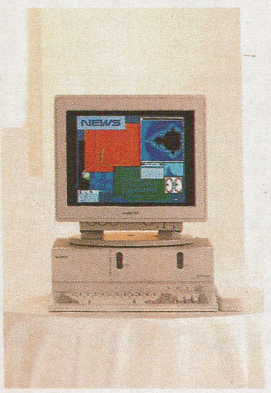
Scanner Editorial

Imagine, spending 8hrs to digitize a drawing into your computer in order to make a 20 minute change. The Planscan Drawing Scanners with selection of software allows drawings to be scanned and edited with AutoCAD and other CAD programs in a fraction of the time of digitizing. The Planscan Scanners are available in 3 models, #2016 - 24" wide up to 400DPI, #3012E -36" wide up to 400DPI, and #4016 -36" wide up to 600DPI at prices to make these a standard in the drawing office. The Planscan software allows filter setting for older drawings, DPI ranges, and 19 different file formats incl, RCL, PCX, DXF, FAX for use with many programs like AutoCAD, Ventura, VersaCAD, Aldus PageMaker, fax etc. There are also programs offered database all your drawing images and create an electronic filing cabinet for quick reference (network-able) printing and security.



PLANON SYSTEMS INC.
2780 Skymark Avenue, Units 5-7,
Tel: (416) 624-6222
Fax: (416) 624-6535

circle no. 83 on reader service card



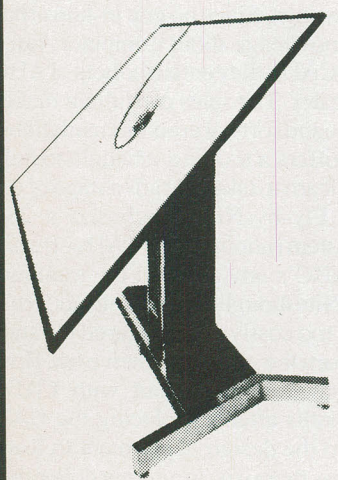
SONY NEWS UNIX WORKSTATIONS

The NEWS family of Sony workstations not only offers compact high performance but also leads the way in network computing. The Open Distributed Processing capability of these workstations helps build a heterogeneous, easily expandable network of shared resources. The dual-processor architecture demonstrates its power in I/O-intensive applications, delivering a constant CPU processing speed regardless of I/O loads and application programs. A high resolution (1280 x 1024) monitor incorporated in the system makes it ideal for CAD/CAM application and with optional video interface boards it is now possible to combine video images with computer-generated texts and graphics.

circle no. 84 on reader service card

Introducing

HI-STATE "THINLINE" OEM SERIES DIGITIZERS



NEW FROM

GENTIAN

State of the art, cartographic quality at a low price.

Superior bonded grid construction on a lightweight 1" super strong honeycomb base. Sizes in 12" x 18", 18" x 24", 24" x 36" and 36" x 48". Includes micro-processor controller, menu, CSA power supply, RS232 Cable and 16 Button Cursor. Optional power pedestal or de-luxe manual pedestal. Ideal for CAD CAM, industrial, educational, medical applications.

Compatible with popular CAD, Graphics and Mapping software.

GENTIAN ELECTRONICS LTD.

P.O. BOX 1240
STITTSVILLE, ONTARIO, CANADA K2S 1B3
PHONE: 1-613-836-3987 FAX: 1-613-836-7526

circle no. 85 on reader service card

Why Training is Needed

When you learned math in high school, those math texts looked like caveman scribles on a wall. It always made life much easier when a good teacher shows you how. Once you got the basic concept you could fend for yourself through the text (hopefully). The same holds true (and even more so) with computers, especially when putting them to work in highly specialized areas such as CAD. What's not normally realized (especially by management) is that when you have a highly skilled CAD professional, you have two employees rolled into one. First, this person must be great at his/her profession. Using Fly-by-Nite as a company example, let's use an electrical designer. For that person to be highly proficient at CAD, he/she needs a good understanding of how the computer system they are using works, what to expect from it, what it can (and can't) do, etc. Now, if we take this highly skilled design professional and stretch them to their physical and mental limit, you have your average overworked, stressed-out employee. To management this is called 'getting your money's worth'. This designer doesn't have time (his nor the company's) to waste. The sad fact is that just as in high school, design staff need training, at least initially. So this raises the question...

Who Should Be Trained?

Contrary to popular belief, more than just the design staff need CAD training. To be truly effective, three levels of training are necessary. We'll classify them as: management, key CAD person, and CAD operators. Most never think of management as being in need of training. Think about it for a moment. Who provides financing, approval/disapproval, decides what technologies are introduced into the company, etc. How can they make an intelligent decision if they haven't a clue about the technology, yet alone what it can do? Management wouldn't need to learn how to use a CAD system (although if they had that knowledge it wouldn't hurt). They do need to learn what is available, at what price and in what areas can CAD best help the company in the design/drafting stage. The key CAD person should be the one most well versed in the operation of the CAD system from both a hardware (computer, plotter, etc) and software (the actual CAD program) point of view. This one would also be in charge of setting up any new software releases and together with management, establish CAD 'standards'

SPECIAL ISSUE!

TOSHIBA ISD

PORTABLE

MONTHLY

INFORMATION SERVICE FOR DISTRIBUTORS/END USERS

TOSHIBA NOTEBOOK COMPUTERS ARE HERE!

The incredible new Toshiba T1200XE and Toshiba T1000XE notebook personal computers are now available in Canada, further establishing Toshiba as Canada's 'First Family' of laptop/portable computers.

THE T1200XE AND THE T1000XE—

TWO EXCITING NEW NOTEBOOK PERSONAL COMPUTERS FROM TOSHIBA!

TWO EXCITING NEW ADDITIONS TO CANADA'S 'FIRST FAMILY' OF MICROCOMPUTER PRODUCTS!

T1000XE

The new T1000XE, truly a lightweight wonder at less than *six pounds*, provides full desktop PC performance—but in a slim-line, notebook design. The T1000XE's tiny proportions include an 80C86 processor, 20Mb internal hard drive, a beautifully crisp backlit display, and an 82-key keyboard with all industry-standard ports. Toshiba continues to provide unbeatable price/performance value!

T1200XE

The 1200XE is the ultimate personal productivity tool, ideal for today's mobile executive and busy office environments. Featuring an 80C286 microprocessor, internal 20Mb hard disk drive, 3.5" 1.44Mb internal floppy disk drive, and an incredible sidelit display, the new T1200XE is the ideal solution for every computing need, and it weighs less than *eight pounds*.

T1000SE – ENLIGHTENMENT AT LAST

WITHIN THE SIX POUND FRAME OF THE T1000SE EXISTS THE SOUL OF A PC MASTER. THIS SECOND

generation performer is even lighter than its predecessor, the T1000, and features an 80C86 microprocessor at 9.54 MHz, 1Mb standard RAM expandable to 3Mb, **industry-standard** 1.44Mb 3.5-inch media-sensing floppy disk drive, full-sized keys, and industry standard ports including a dedicated modem slot.

You don't have to purchase costly additions or neglect existing software or hardware with the fully MS-DOS compatible T1000SE. With a rechargeable battery, a 640 x 400 double scan electroluminescent backlit display, and a port for future expansion, it allows optimum existing hardware usage. With the T1000SE around, there's no need to get heavy when it comes to high speed processing.

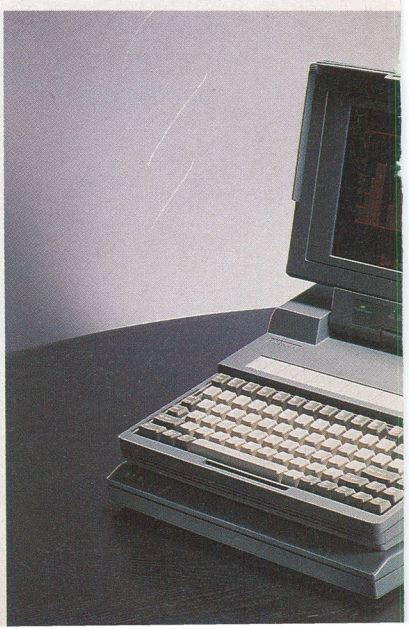
TOSHIBA LA ONLY IN CA

TOSHIBA HAS LANDED ON SIVELY DESIGNED AND MANU

Toshiba's unprecedented LANport modular docking station. The LANport system is a two-piece desktop docking unit/portable expansion chassis that allows incredible expansion while increasing productivity and portability for most existing Toshiba portable microcomputers.

The LANport I desktop docking station and the LANport II portable expansion chassis are intended to work together as two separate units. Although each product can function independently, when combined, LANport I and II create a unique desktop expansion system for a LAN environment.

LANport I is a stationary desktop docking port that allows all office peripherals to be permanently connected to the docking station, simplifying portability and expanding flexibility. Sup-



T O S H I B A

NPORT – NADA

CANADIAN SOIL. EXCLU-
FACTURED IN CANADA IS

porting two standard half-height (or one full height) storage devices, LANport I accommodates floppy or hard disk drives, tape backup systems, or optical storage devices. Disconnection from the docking port is effortless, leaving all peripheral connections and storage devices intact.

The LANport II portable expansion chassis connects to the underside of a Toshiba portable and provides two full-length industry standard 16-bit expansion slots and one Toshiba proprietary expansion slot. You can either carry it away with the portable, or disconnect it and leave it behind.

The LANport system is a superb example of Toshiba transcending the barriers between portable and desktop expansion to protect our users' investments.

T3100SX – THE ULTIMATE PORTABLE DESKTOP PC WITH A BATTERY OF FEATURES

NOT ONLY DOES THE POWERFUL T3100SX OFFER TWO INTERNAL LIGHTWEIGHT AND RECHARGEABLE BATTERIES,

but it features an exceptional VGA gas plasma display – the "perfect combination". It also boasts a long list of exceptional features. Powered by a 16MHz 80386SX microprocessor, this portable offers 32-bit processing power and standard 1Mb RAM expandable to 13Mb with Toshiba's 4Mb DRAM (dynamic random access memory) technology, ideally suited for the OS/2 environment.

As well, the T3100SX provides a media-sensing 3.5-inch 1.44 Mb floppy disk drive and a 40Mb hard drive, industry standard ports including two serial ports, a Toshiba proprietary slot and a dedicated modem slot for complete communication and expansion capabilities. The detachable VGA gas plasma screen with 640 x 480 resolution, 16 grey scales, "sleep" mode, automatic off for hard drive and low power consumption, single this computer out as a portable powerhouse. The T3100SX is a veritable quantum leap towards the perfect portable desktop PC.

T O S H I B A P O R T A B L E

THE FAMILY PORTRAIT

JUST IN TIME FOR THE FAMILY REUNION, CANADA'S 'FIRST FAMILY' OF PORTABLE MICROCOMPUTER PRODUCTS.

CASES IN POINT

Portable and pragmatic—Toshiba makes it possible for you to be fashionably mobile with a whole range of carrying cases.

- **Computer Cases**

Name your portable computer and we've got a case. Made of rugged nylon and vinyl with handles or shoulder straps.

- **Softsided Printer and Computer Bags**

What's the combination? These are combination carrying cases for printers and computers. Available in both nylon and leather.

- **Hardsided Carrying Cases**

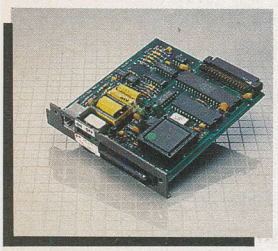
A flexible alternative for executives who don't want to give up briefcase security. Available in vinyl and leather.

TOP COMMUNICATORS

Opening the lines of communication for today's technology!

3270 and 5250
Toshiba's IBM/IRMA-compatible Adaptor Cards.

Token Ring LAN Adaptor Card
IBM PC LAN compatible, 4 - 16 Mbps data rate.



The PDT8023
Toshiba's thin-cable Ethernet card.

The PDT508
Toshiba's Arcnet network interface card.

COMPUTERS

T1000
Full function, low cost desktop PC in a 6.4 pound package.

T1200HB
A flexible, portable, upwardly mobile computer.

T1600
Battery-powered mobile productivity and AT performance.

T3100e
Price/performance leader, with portable PC convenience and AT power.

T3200
Desktop AT power and performance in a portable package.

T3200SX
Desktop '386SX functionality with three internal slots.

T5100
Full '386 power and performance in a portable 15-pound package.

T5200
The ultimate '386 portable computer, for power computer users.

T8500/25
A multiuser, multitasking personal business system, LAN/UNIX file server.

PRINTERS

P301
Rugged AC or battery-powered, 4.2 pound truly portable printer.

P311
Affordable, portable 24-pin printer quality at a 9-pin price.

P321SL/341SL
Narrow and wide carriage quality 24-pin printers.

P351SX
The ultimate 24-pin printer, Toshiba's best dot matrix printer.

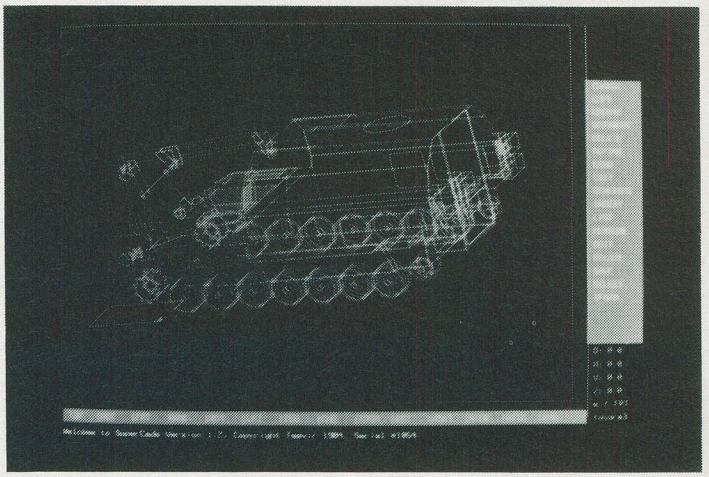
PageLaser6
Richly featured 6ppm laser printer...with postscript.

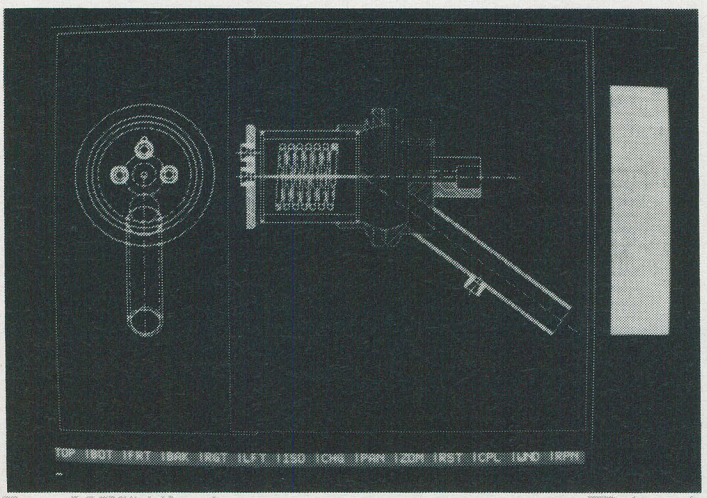
PageLaser12
High volume, high value, 12ppm laser with superb paper handling.

circle no. 90 on reader service card

for the smoother use of CAD in the design office. These standards would include: setting drawing back-up procedures, uniform drawing settings for text, dimensions, plotting pen thicknesses, just to name a few. If the design department is large enough, more than one person may be assigned to this post to form a CAD team.

From experience it can get to be a heck of a job when you have to support more than 20 CAD users. The person(s) selected for this post must possess the rare quality of being able to apply their computer knowledge to the technology at hand. The CAD operators need to learn enough about the CAD software to make the best use of it for their design work. They need initial training as well as follow-up training at regular intervals, especially in the early stages of CAD implementation. All this logically leads to the question of...





Where to Get Training?

In general, there are three ways of obtaining CAD education. The three methods are: colleges/instituttes, consultant/dealer, and books. Let's examine each. Colleges and other *en masse* learning institutions are great for CAD, and most teach AutoCAD. The advantage of learning in the college environment is that the training programs are usually long enough (about 6-10 weeks on average) to allow enough time to grasp all the CAD concepts being put forth. Colleges also are one of the least expensive forms of training. However, most CAD courses taught in a college have an instructor to student ratio typically of about 1:15 and the courses are general in nature. You may not get the exact specifics that you may require. This is a good avenue for training new CAD operators.

Consultants or your CAD dealer may also offer training. This is typically the most hefty in investment but yields some great advantages if done properly. The instructor/student ratio is low, typically 1:3 and many times one on one. The course material is based upon your company's needs. This gives you more of a chance to learn exactly what's important to you in your company's unique situation. This route is best for training or refreshing the key CAD person's skills. It's also the perfect vehicle for tailoring a brief but informative CAD overview for management. The last method (the book — this includes the manual) is where both the Key person and other CAD personnel what to end up at this stage. From their base knowledge and experience, staff can improve their skills in key areas by reading and applying knowledge gained from books, manuals, periodicals (like this one) and so forth.

Paying the Bill

Since any amount of training costs a certain amount of green stuff, how does one go about paying for all this information? Well, that depends on where you live. In Ontario for example, if your company is in the design or manufacturing sector and you meet employee size requirements, your company can get anywhere up to 80% funding from the Ontario government's Skill Development Program to help defer training costs. This can be a considerable saving and is worth checking out. In Ontario you can get information by simply inquiring about the Skills Development Program at your local community college branch in your area.

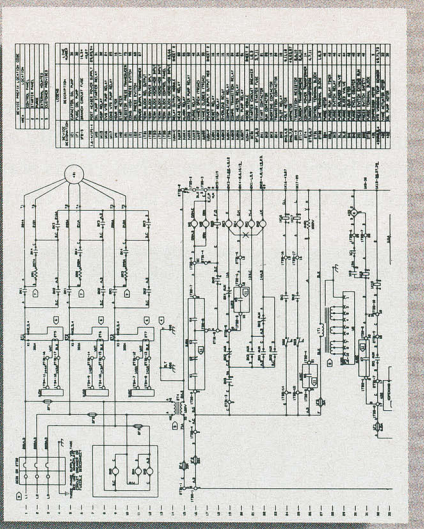
For those in other provinces and territories, check with your local government offices to see if such programs exist in your locality. If this not the case at least check out what forms of education qualify as a company expense fot taxe purposes.

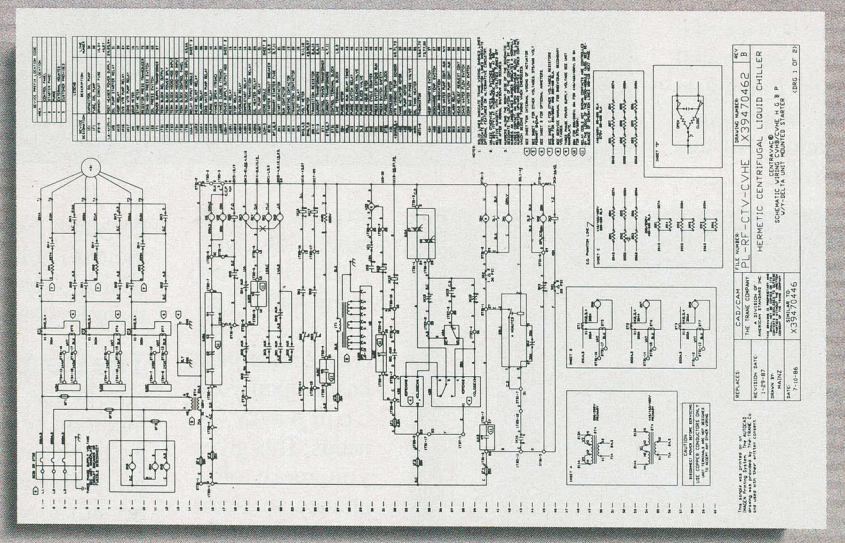
The Best Method

...is to use a combination of all three methods, or what you feel best suits your group. Once you've started a training program, make plans to expand upon your organizations knowledge and use of CAD. It is an ongoing process. Just remember that proper training is like prevention. And an ounce of prevention is a far cry cheaper than a pound of cure.

k

Why accept
8 1/2 x 11





When you
can have
affordable
11 x 17

the QMS-PS 2200E lets you tell the whole story

Sometimes an 8.5" x 11" page can only tell half the story. Now QMS brings you enhanced performance and superior print quality in an Adobe ® PostScript® laser printer with 11" x 17" capability, with HPGL .

Because the QMS-PS® 2200E can print pages up to and including a standard 11" x 17" spread, it works not only for the designers in your company, but will also handle the most demanding jobs of everyone else. With this QMS® printer you can create everything from annual reports to giant spreadsheets, charts and engineering graphics.

The QMS-PS 2200E is a real work-horse. Features such as 22 page-per minute output (11 ppm for 11" x 17"), a 16 MHz 68020 processor, 4 MB of RAM, HP GL® and HPPCL® emulations, 39 resident typefaces and advanced paper handling make this one of the best all-round PostScript printers on the market.

Isn't it time you got the whole PostScript printing story? Call **1-800-361-3392** for the nearest QMS Canadian dealer.

QMS™

QMS Canada Inc.

Montreal Office	1-514-333-5940
Toronto Office	1-416-673-8060
Ottawa Office	1-613-563-1177
Calgary Office	1-403-266-3500
Vancouver Office	1-604-872-0631

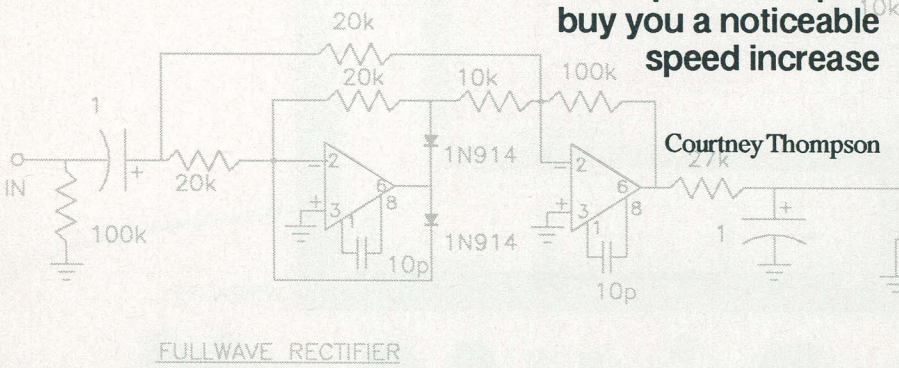
QMS Canada Inc., 9630 Trans-Canada Highway, Montreal, H4S 1V9. © 1989 QMS, Inc. The following are trademarks or registered trademarks of their respective companies: QMS, the QMS logo and QMS-PS of QMS, Inc.; Adobe and PostScript of Adobe Systems, Incorporated; HP GL and HPPCL of Hewlett-Packard Company .

circle no. 94 on reader service card

Introduction to Electrostatic Plotters

Simple techniques buy you a noticeable speed increase

Courtney Thompson



The technology of the pen plotter has been well worked out, and mass production has lowered the price enough to make them an industry favorite. However, users will agree that the biggest disadvantage is very slow speed—it takes a great deal of time to mechanically move a pen, especially if the drawing contains a great deal of fine detail. Several hours is not unusual for a large, complex plot. Furthermore, there are the problems that go with any type of drafting pen: blocked ink flow, gaps, fading towards the end of a line, damaging the paper from repeated passes, etc. These problems have been solved to a great extent by the development of electrostatic plotters.

Electrostatic Technology

Electrostatic plotters are not all that different in principle from the familiar photocopier. A high-resolution print head (analogous to the copier's charged drum) extending the width of the plotter places a high-voltage electrostatic charge on the paper where the image is to be dark; the paper then passes over a toner-dispensing mechanism and the image is formed.

Electrostatic plotters are available with print heads giving resolutions of 200 to 400 dots per inch. Even a 200 DPI plotter produces an excellent print; the 300 DPI approaches the quality of a laser printer, and prints from a 400 DPI can be dazzling.

As an example of electrostatic plotting technology, we've used a Versatec 8510 CADmate. It's a 300 DPI model that takes a roll of paper 36" wide.

Interfacing

As you'd expect, your drawing has to be converted from the usual CAD vectors (in which the parts of the drawing are stored as mathematical entities) to a series of on-or-off dots that correspond to the print head's resolution ("raster scan" or "raster file"). There are two ways to do this. The fastest way is to equip the plotter with all the required electronics to handle the conversion and storage of the file, and it's not surprising that this requires the equivalent of a computer with a vast amount of RAM. While this frees up your CAD computer to do other things during as plot, it raises the plotter price considerably.

The 8510 is an economical alternative. It consists of only the minimum amount of control electronics; your computer does the vector-to-raster conversion and sends the required file to the plotter. In order to give a fast transfer rate, the plotter comes with a interface card for your computer that provides a high- speed parallel output to the included cable. This eliminates the bottleneck associated with the usual low transfer rate of the RS232 serial connection.

Speed

The advantages of the electrostatic method became apparent immediately during testing. The absence of pens and their attendant maintainence was wonderful, and the speed was amazing to those used to watching a robot arm going back and forth over the plot.

A complex drawing roughly 36" by 48" took 13 1/2 minutes using a 386 computer. By comparison, the same drawing on an industry- standard 36" pen plotter required one hour and 35 minutes. (The Versatec 8536, which is the same plotter with an internal processor and lots of RAM, took under six minutes).

Your Computer

Needless to say, turning over the processing task to the CAD computer requires powerful hardware. The minimum requirement (for IBM-compatibles) would be a 286 with a fast hard disk and something like 20 megabytes of free space (the largest E-size drawing requires 17 megabytes of space for processing the raster output). The fastest CPU with a math chip is recommended. Best of all would be a 386/387 or 486 and lots of disk space.

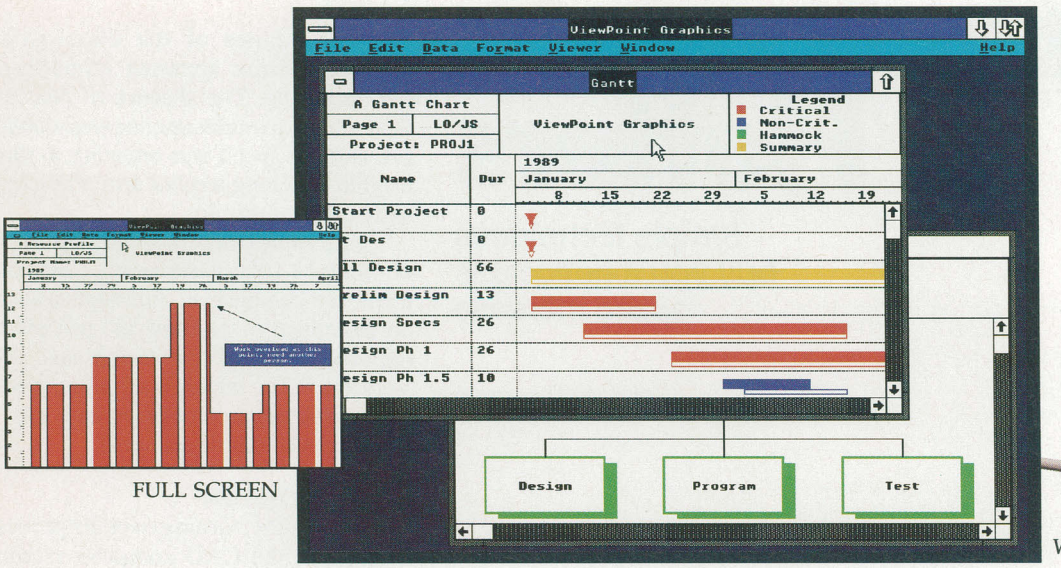
The included software installs easily, though it asks a few questions about interrupts and DMA addresses that some people will find baffling. Fortunately, our interface card was preset for the computer and all the defaults worked perfectly. The file conversion program requires that you plot to a file, using either Autodesk's ADI binary file or the popular HPGL format. The utility then converts your file to a raster type and sends it to the plotter.

Other Features

The small control panel includes a contrast adjustment, and a switch for film or paper. The Versatec 8510 with parallel card, cable, cleaning kit and all necessary software has a list price of $22,900. By comparison, a 36" pen plotter would be in the $14-15 thousand range. To anyone concerned with production rates, the extra price is well worth it. And you can throw away your pens.

Further information on the 8510 and other electrostatic models is available from Versatec, 251 Consumers Road, Suite 802, Willowdale, Ontario M2J 4T5,

The best project manager Just got better.



FULL SCREEN

WINDOWS™

Now, ViewPoint™ 4.0 with Windows™ graphics

They said it. We didn't. Here's what InfoWorld and PC Magazine said about Computer Aided Management's ViewPoint software:

INFO WORLD BEST IN ITS CLASS

"ViewPoint: Easy to Learn and Use; Great Value for Powerhouse Project Management."
Mike Heck *InfoWorld 1989*

PC MAGAZINE EDITOR'S CHOICE

"ViewPoint is an excellent high-end choice. It offers the ability to control massive projects combined with the ease of use more typically found in low-end programs.
Henry Fersko-Weiss *PC Magazine 1989*

That was before ViewPoint 4.0 and Windows.

New Windows-based Graphics. ViewPoint 4.0, with the addition of Windows-based graphics, gives you a complete project planning, management and presentation solution.

Intuitive Windows interface. Use your mouse or keyboard to open several windows into your project, zoom for a detailed view or scroll through a Gantt Chart. Open windows into other programs such as spreadsheets or databases. All, in the intuitive Windows environment.

Charts that communicate. Select and customize charts with real-time point-and-click editing. Control fonts, size, color and the attributes of each chart element. ViewPoint 4.0 includes drivers for popular printers, laser printers and plotters. And much more.

Plans that work. ViewPoint's top-down approach to project management means you can start with the goal and work down to the finest detail. Relate activities. Play "What If." Speed project planning and reports with templates. And with ViewPoint, you won't run out of power right in the middle of a critical project.

Want to know more? Call us toll free, or return the coupon below. We'll send you a comprehensive brochure and the ViewPoint 4.0 demo disk.

ViewPoint
PROJECT MANAGEMENT SOFTWARE

1-800-668-0726

circle no. 99 on reader service card

THE CAD T.E.A.M.

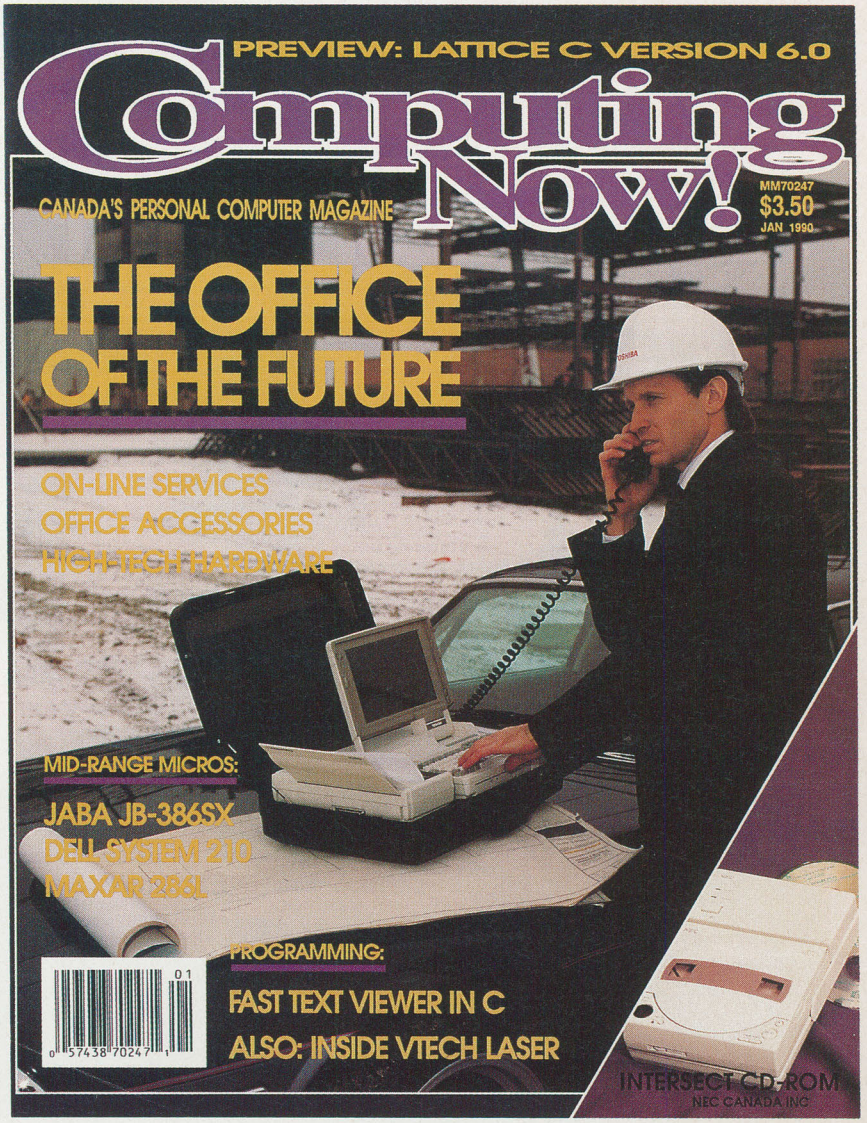
TORONTO • OTTAWA • MONTREAL • VANCOUVER
BOSTON • NEW YORK

1740 Massachusetts Ave.
Boxborough, MA 01719
1-800-668-0726

1205 Ampère, Ste. 300
Boucherville, Quebec
J4B 7M6
514-449-4581

The Pentagon Building
2550 Argentia Rd. Suite 113
Mississauga, Ontario L5N 5R1
416-542-1382

A very special offer to CAD/CAM users



THE CAD/CAM COMPANION

This offer is to emphasize the importance of Computing Now! as a companion to the CAD/CAM computer user, and is a one-year subscription at the rate of **$12.95,** almost a **75%** reduction on newsstand rates. This rate will include the Annual Computing Now! Microcomputer Source Guide.

It's our way of showing you the flexibility of our technical publications, and that we'd like you as a reader, but you must act **NOW!**

The following strict rules must apply:
We must receive your cheque or credit card information by July 15, 1990.
You can only use the subscription card in the accompanying issue to subscribe.
If it is gone, we will accept a photocopy of this advertisement.
This rate cannot be used in conjunction with any other offer.
This offer will apply to Computing Now! subscriptions only and not our other publications that may be described in this issue.

PLEASE ACT NOW!

If it is more convenient, call, with credit card details:
(416) 445-5600, or fax 416-445-8149

Jaba Power Supplies

Your Computer Engery Source

more than **48** different types of power supplies and cases for your choice....

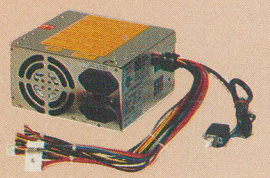
All models are **CSA** approved, all series out-put power available in 150W, 180W, **200W,** 230W, 250W and 300Watt

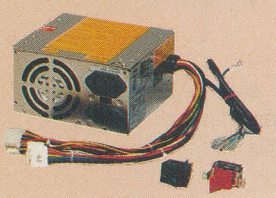
SPQ series

Dim.: L150 x W140 x H86 mm

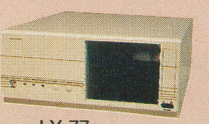
APPROVED
LR83386

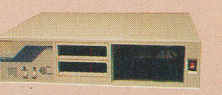
SPQ series

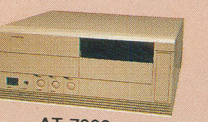


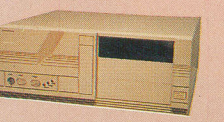


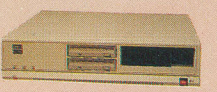
Dim.: L150 x W140 x H86 mm


LY-77


FCC-701


AT-7000

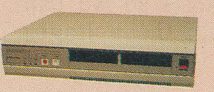

MA-03


LY-62

TWR-44

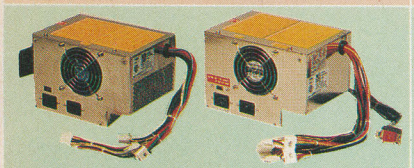
TWR-33

FCC-606


IET-302

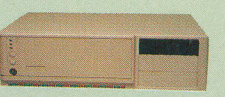
More....

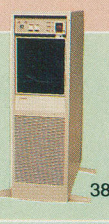
SPA series



Dim.: L213 x W150 x H150 mm

SC-AA012


SC-AA022


386-01

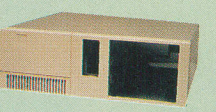
32-398

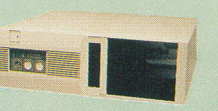
More....

SPB series

Dim.: L165 x W150 x H150 mm

CT-03

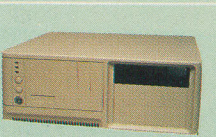

LY-21


32-570

More ....

SPC series

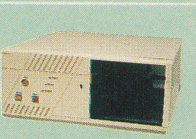
Dim.: L156 x W155 x H143 mm

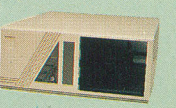

SC-MA022

More ....

SPF series

Dim.: L156 x W152 x H145 mm

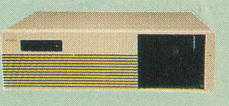

CM-2000

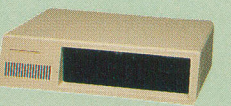

MAT-217

More ....

SPM series

Dim.: L225 x W140 x H120 mm


LY-31


LY-03

More ....

Jaba System Inc. (Power Supplies Centre)

circle no. 98 on reader service card

EASTERN: **Jaba System Inc.** 80 Shields Court, Markham, Ontario L3R 9T5 • **Tel : (416) 477-6363** • Fax : (416) 477-6891

WESTERN: **Atco System Inc.** 150 - 12871 Clarke Pl., Richmond, B.C. V6V 2H9 • **Tel: (604) 276-9986** • Fax: (604) 276-9983

Some Useful Rules And Formulae

Ron C. Johnson

In last month's segment we talked about how to calculate equivalent resistances. We said that resistances in series are just added together but to determine the equivalent resistance or resistors in parallel the simplest way was to use conductances. So:

$G_T = 1/R_1 = 1/R_2 + ... 1/R_N$

where G_T is conductance in Siemens, S, and N is the number of resistors.

This will calculate the equivalent resistance for any number of parallel resistors. But if you have just two resistors in parallel it may be simpler to use what is called the "product over sum" method. (This is just a derivation of the conductance method.)

$R_{eq} = R_1 X R_2 / R_1 + R_2$

If you have more than two resistors in parallel, any two can be reduced to an equivalent which can then be combined with the third.

In the case where resistors of the same value are in parallel the value of the resistors divided by the number of resistors will give the equivalent:

$R_{eq} = R/N$

Voltage Divider Rule

Kirchoff tells us that around any loop the voltage rises must equal the voltage drops. Last month we calculated the total resistance in a series loop and found the total current. We then multiplied the value of a particular resistor times the current to find the voltage drop across that resistor. Voltage divider rule is just a quicker way to do the same thing.

Given a series circuit with two resistors (R_1 and R_2) we can find the voltage across either one by using the following formula:

$V_{R1} = E X R_1/(R_1+R_2)$
or
$V_{R2} = E X R2/(R_1+R_2)$

What the formula is saying is that the voltage across the resistor will be proportional to the ratio of that resistor to the total resistance of the circuit.

Current Divider Rule

Current divider rule is used to determine how much current splits down the branches of a parallel circuit and as in VDR it uses a ratio. In this case, however, the current through a resistor in one branch is proportional to the ratio of the resistance of the other branch to the total resistance.

$I_{R1} = I_T X R_2/(R_1+R_2)$
and
$I_{R2} = I_T X R_1/(R_1+R_2)$

and
$R_T = 8ohms$

The same could be accomplished by configuring the speakers as in Figure 5 where two sets of 8ohm speakers in parallel are connected in series. Each parallel set has an equivalent resistance of 4ohms. When the two equivalents are added together we get 8ohms.

Some Theory

So series-parallel networks can be useful and, in fact, most practical circuits have complex combinations of series and parallel branches. Quite often we need to be able to analyze these networks so we can predict the voltages across components, currents through them, power dissipated in specific devices or the equivalent resistance of a combination of components.

And most of it can be done with the help of our old friends, Ohm and Kirchoff.

Figure 5 shows a basic series-parallel circuit with a DC voltage source. The total current flowing out of the voltage source is I_T. All of this current flows through R_1. It then splits and some flows down through R_2 and some through R_3. We will call these currents I_1 and I_2 respectively.

The sixty-four thousand dollar question is: how much will flow through each resistor? Also, how do we calculate R_T, I_T, the power dissipated in each resistor... Okay, so it's more than one question. What is the approach?

Usually the first step is to find the total resistance in the circuit; the total load presented to the power source. This will allow us to determine the total current flowing in the circuit. The trick is to combine the resistances in the correct order. Any time the current in the circuit splits we must have a parallel section in the circuit. In this case it is R_2 and R_3. We can't combine R_1 with them until we know their equivalent resistance. So we either add their conductances and then convert back to resistance or we can use the product over sum rule described in the Rules and Formula section. Once we have an equivalent resistance we can redraw the circuit (Figure 6) with the R_2 - R_3 combination as a single resistor and place it in series with R_1. From there we simply add the two resistances together to get R_T.

Try this example. It's easy and it will help you get comfortable with the procedure. Again referring to Figure 5 let's make R_1 a 5.6k ohm resistor, R_3 a 3.3k ohm and R_3 a 2.2k ohm. (These are all standard EIA resistor values so you could set this up and confirm that it works.) The voltage source is a 12 volt battery but practically any low voltage DC source would do for experimentation. We said we would have to determine the equivalent resistance of the parallel branch first. Using the product over sum rule we get:

$R_{eq} = 3.3kohm X 2.2kohm / 3.3kohm + 2.2kohm = 1.32kohm$

We then put the R_{eq} in series with R_1 and add them together.

$R_T = R_1 + R_{eq} = 5.6k\ ohm + 1.32k\ ohm = 6.92k ohm$

We could now redraw this again as a simple series circuit: a voltage source, one resistance and a current carrying path. But let's just calculate the total current flowing out of the voltage source:

$I_T = E/R_T = 12v/6.9k\ ohm = 1.73\ mAmps$

So now we know the source voltage, the total resistance in the circuit and the total current drawn from the supply. The purpose of our analysis will determine where we go from here. We could find the total power dissipated in the circuit using $P = I_T X E$ and the information we have so far. Quite often though we want to know how the current splits through R_2 and R_3. There are a couple of ways of finding this.

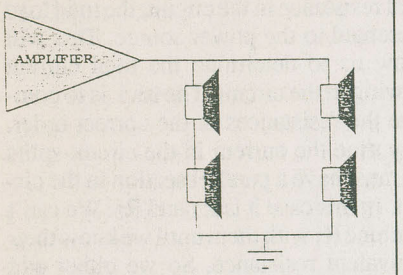


Figure 3. Four 8 ohm speakers in series-parallel.

We know one way using the tools we already have. You can check out the Rules and Formulae section for another way called *current divider rule*.

Take a look, again, at Figure 6 where we have redrawn the circuit diagram showing the R_2 - R_3 parallel combination as an equivalent resistance. We have seen this circuit before and know how to find the voltage across R_{eq}. V_{eq} would be equal to R_{eq} times the current through it since R_{eq} is the equivalent resistance of the parallel section and I_T flows into that combination.

If V_{Req} is across R_{eq} then the same voltage is across the parallel combination of R_2 and R_3 which means that each resistor has the same voltage, V_{Req}, across it. To determine the current through either one of those resistors we just use Ohm's Law:

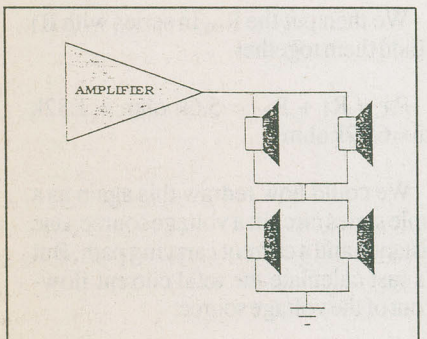


Figure 4. Four 8 ohm speakers in series-parallel.

$I_{R2} = V_{Req}/R_2$
and
$I_{R3} = V_{Req}/R_1$

These two values of current should add up to I_T which was calculated before. (Just check for practice; go ahead and calculate these currents and check.)

All of this brings up some rules which, while they are not absolutely necessary to know, can be useful in this process of circuit analysis.

I know, more rules and formulae, but they are pretty simple and can help streamline your analysis technique.

KCL

Kirchoff had two good ideas. Kirchoff's Current Law states that the algebraic sum of all the currents entering and leaving a node will equal zero. What this really means is: "what goes in has to come out". A node is an electrical connection of two or more components. If current flows in from one branch the same amount has to flow out somewhere. In our previous example the current, I_T flowed into Node A, where R_1 connects to R_2 and R_3. The same amount of current—the total of I_2 and I_3—must equal I_T. Another way of calculating how much flows in each branch (Current Divider Rule) is shown in the Rules and Formulae section along with a method of finding the voltage across a resistor in a series circuit (Voltage Divider Rule).

Meters

Probably most of you have had opportunity to use a meter at one time or another. Perhaps you have one of your own. Our purpose here is not to cover the use of meters as much as to talk about how meters relate to this subject of series-parallel circuits. Even so, we'll take a general look at meters as a way of introduction.

We could categorize meters in several ways. We could differentiate between analog and digital meters, bench meters and portables, specialty meters versus general purpose, or high accuracy versus economy units.

For our purposes let's talk about functions. The basic meter we are considering measures voltage, current and resistance, the quantities we have been dealing with in this series. In addition to DC values most meters of this type will measure alternating currents and voltages. Older units were called VOMs (Volt Ohm Meters) while others were TVMs (Transistorized Volt Meters), VTVMs (Vacuum Tube Voltmeters), and more recently DVMs (Digital Voltmeters). In all cases, though, the same quantities were measured. Before the advent of digital technology and the availability of digital displays, bench and portable test meters used various kinds of electromechanical meter movements for indication. Many were excellent pieces of test equipment considering the delicacy of their meter

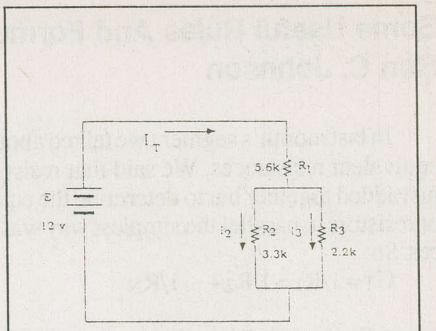


Figure 5. A basic series-parallel circuit.

movements, difficulty of interpreting scales and limited specifications. (More on that later.)

Digital meters, which have replaced analog for most applications, have benefited, not just by their solid state displays but also by the improved technology used in their input sections. In addition to being more rugged, generally, they can fit more functions in a smaller package and give better specifications.

We'll take a look at some actual products and their use in another segment.

The important concept that must be understood is that although the equipment available is generally very good, meters do have an effect on the circuit they measure. Figure 7 shows a simple series circuit with two resistors, R_1 and R_2 and a 20 volt source. Let's imagine that you have been asked to measure the voltage

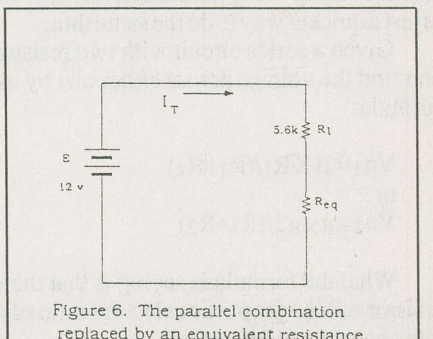
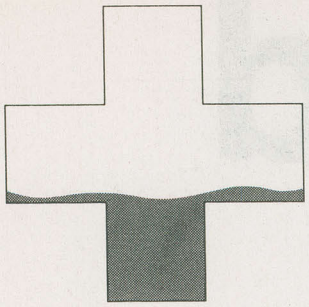


Figure 6. The parallel combination replaced by an equivalent resistance.

across R_2 with the meter shown. If the meter was perfect it could be connected across R_2 and it would indicate the voltage dropped there. We could predict what the voltage should be by using the voltage divider rule to calculate it.

A perfect or ideal meter would look like an infinite resistance and so would draw zero current from the circuit and consequently have no effect on it. However,



IT TAKES MORE THAN BLOOD TO KEEP THE CROSS RED.

To The Red Cross, your money is also precious. We've served Canada for almost 100 years. And we can only continue with the financial support of people like you.

Your generosity is our life-blood. Please give what you can as soon as you can. Contact your local Red Cross.

We welcome VISA and MASTERCARD.

HELP KEEP THE CROSS RED.

The Canadian Red Cross Society

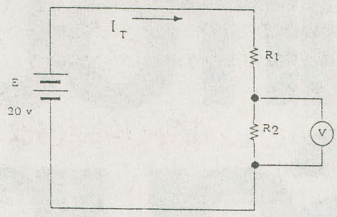


Figure 7. Voltmeter loading.

meters are never ideal. Such is life. In reality meters have an internal resistance which, while very high, is a finite value. So in order to use our meter intelligently, we need to know under what conditions it will "load down" the circuit. If it loads down the circuit it will give significantly erroneous readings.

For example, digital meters often have an input resistance specification of

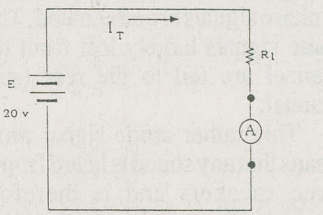


Figure 8. Ammeter insertion loss.

over 1M ohm which is very high — much higher than most analog VOMs. If R_1 and R_2 in Figure 7 were 100ohm resistors we could calculate V_{R2} to be 10 volts. If the meter (1M ohm) were connected across R_2 we would have to consider a 1M ohm resistor to have been connected across R_2. We would then re-calculate V_{R2} based on an R_{eq} of 100ohms in parallel with 1M ohm. In this case the change in R_{eq} would be negligible.

But what if R_1 and R_2 were 1Mohm each?

In that case V_{R2} should still be 10 volts, because the ratio of the resistors is still the same, but now R_{eq} would be a 1M ohm resistor in parallel with a 1M ohm meter resistance which would equal 500k ohm. Using the voltage divider rule and the equivalent resistance we would get:

V_{R2} = (500k ohm/1.5M ohm) X 20volts=6.67volts

So the meter would read 6.67 volts even though it should be reading 10 volts. This is a case where the meter is loading down the circuit. Sometimes this is difficult to avoid but at least being aware of the problem helps to understand why you are getting unexpected readings. This will happen when measuring voltages across high values of resistance.

A similar situation can come up when measuring current. We have been saying that we always talk about the current *through* a component so it make sense that in order to measure current we have to break into the circuit and route the current through the meter. Ideally, the meter, when measuring current, would have zero resistance, thereby contributing nothing to the total circuit resistance. Practically speaking, the resistance of an ammeter is very low, usually just a few ohms. This presents no problems in some cases, but, again, there are circumstances where it becomes a problem.

Figure 8 shows a simple series circuit with an ammeter connected in series. The resistance in the circuit is 1k ohm and the power source is a 20 volt supply. Without the ammeter in the circuit the current would be:

I_T=20 v/1k ohm=20 mA

With the ammeter in the circuit we are adding 10ohms to the total resistance. Ten ohms is small compared to the 1k ohm resistor and will make practically no difference to the total current. On the other hand, if the circuit resistance was 20 ohms (which would give a current of 1 amp) adding the ammeter to the circuit would change the total resistance to 30 ohms instead of 20 ohms. This would limit the current to 667 mA instead of 1 amp so that meter would be affecting the operation of the circuit.

Again we must be aware that when connecting an ammeter in series with a circuit which has a low total resistance that the meter will affect the circuit noticeably.

Well, that about wraps it up for this month. Next time we'll talk about ideal and practical DC energy sources before we move on into some basics of Alternating voltage and current.

Hope I didn't load down your circuits.■

FEATURE

Surround Sound

Audio processors that make your living room sound like the local theatre.

Ian Graham

When you watch a movie in the theatre, the soundtrack assails you from all directions. The dialogue comes mainly from the front of the theater while the music and sound effects blast from a battery of speakers alongside and behind the audience. A shout from the left, an explosion to the right, an aircraft screaming overhead towards the rear left emergency exit — it all helps to place the audience in the middle of the action.

When a video tape of the same film is played at home, the three- dimensional sound experience is lost. Even a stereo video recorder and television set can't do it justice. That being so, it might surprise you to learn that when a movie is released on video, the information used by the cinema sound system to separate out the various audio channels and feed them to the cinema's impressive array of loudspeakers is transferred onto the humble video tape along with the film.

Although the home video recorder and television cannot decode the audio channel information on the tape, a surround sound processor can. Sound processors capable of recreating cinema-quality sound in the home from ordinary prerecorded video tapes of movies are now beginning to come onto the market. Prices are still relatively high for the best processors, but hi-fi amplifiers and even video recorders with built-in surround sound decoders are already becoming readily available.

Two Into Four

Most movie sound is recorded in Dolby Stereo. Although it's called Dolby *Stereo*, the tape's two audio tracks contain enough information to decode *four* audio channels. The simplest processing system, called "Dolby Surround", creates four channels from the two on the tape by a rather rudimentary technique.

The left and right channels are added together and fed to the center front speaker. Signals that are in phase, such as dialogue, are reinforced by this, while out of phase signals are attenuated. The out of phase signals largely lost from the front channel are fed to the rear (surround) channel.

This rather crude signal processing means that any sound is heard from at least three speakers and is therefore less precisely directed than in the cinema. In fact, some Dolby Surround processors do away with the center front speaker altogether and reduce the system to three channels—left, right and surround.

For convenience, so that the system can be set up with two stereo amplifiers, this version of the system uses one stereo amplifier for the left and right channels and a second stereo amplifier for two identical surround channels. A 20 millisecond time delay is also inserted between the left-right and surround channels. Separation between right and left channels or front and surround channels is quite good, but separation between either side and center or either side and surround is poor.

Some Dolby Surround decoders are available as separate add-on units, but most are built into audio amplifiers or AV Amplifiers (amplifiers capable of switching both audio *and* video signals). Amplifiers with built-in surround sound decoders normally also have two extra channels of 30W or thereabouts to drive the surround speakers.

The companies that market surround amplifiers normally offer small surround speakers as optional extras.

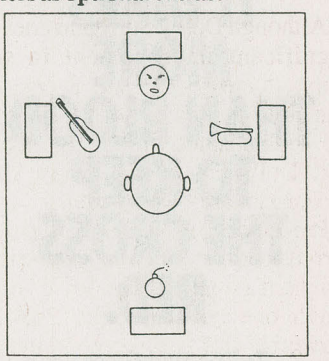


Fig. 1. The original movie soundtrack has four channels - one for dialogue and three for music and sound effects. These are combined into two tracks during the transfer onto video tape.

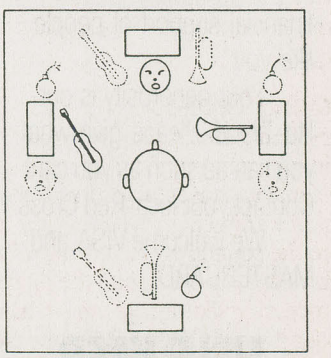


Fig. 2. Most basic processors cannot separate the four channels sufficiently to recreate the theatre soundtrack accurately. Any sound comes from at least three speakers.

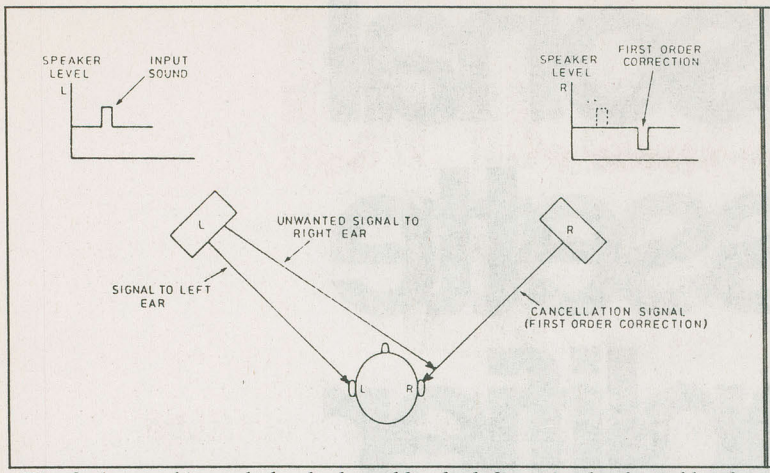


Fig. 3. A sound intended to be heard by the left ear is also heard by the right ear a fraction of a second later. It can be removed from the right ear by sending a cancelling signal. This is called first order correction. However, the correction signal may be heard in the left ear, so a second order of correction may be necessary. Higher orders of correction produce more accurate sound steering.

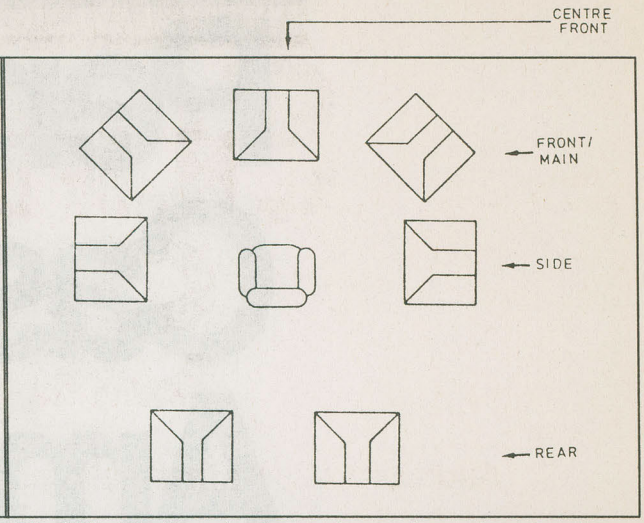


Fig.4.The ideal speaker layout for movies and music using a Pro-Logic processor. A subwoofer may be added.

Although Dolby Surround does offer a significant improvement in sound quality, it clearly doesn't recreate the sound field generated in the cinema. A more sophisticated processing standard called "Dolby Pro-Logic" comes closer to the professional cinema system.

Pro-Logic boosts the dialog sent to the front speaker and removes it from left and right. If a sound is intended to be heard through one channel only, Pro-Logic removes it from the other channels. Similarly, if a sound is intended to be heard somewhere between the speakers, Pro-Logic balances the signal strengths of the various channels to make the sound appear to come from thin air at the intended position. This ability to steer sounds around a room is Pro-Logic's great strength.

Delaying Tactics

The system's electronics must react to incoming information from the tape in real time, sensing phase and loudness relationships and adjusting signal output levels before the sound had to be passed to the speakers to keep pace with the picture. If the processing should take longer than this, the sound would be heard before the onboard logic began to steer it, presumably producing some very odd and nightmarish effects. This places very demanding limitations on the time available for signal processing. Some decoders buy extra time for signal processing by deliberately delaying the whole signal by up to 20 milliseconds. It seems a lot, but it's about the same delay as one would experience in the front row of a theatre, and so the lag between picture and sound is quite acceptable.

Badly recorded source material can cause problems. Any misalignment of the playback heads or the film when the movie is transferred from film to video tape can produce small time differences between the two audio tracks. Errors of up to 50 microseconds are common and the time difference between the tracks may vary as the tape plays.

Fifty millionths of a second doesn't sound much, but especially at high audio frequencies even this tiny error can produce significant differences in phase between channels. As the decoder uses these phase relationships to determine where sounds should be steered to, errors in phase will produce incorrect steering.

There are three ways of overcoming this. Cutting the treble in the surround channel where steering errors are likely to be the worst masks any differences between them and the other channels. Alternatively, deliberately narrowing the separation between left and right channels subjectively reduces any treble differences between the.

The best Pro-Logic decoders can detect and correct these input errors, so that even defective software can give satisfactory results without the need to cut or attenuate any part of the input signal. The Lexicon CP-1, for example, does this by continually checking that the dialog is centred accurately and automatically correcting any errors that tend to shift it to either side. It does this so efficiently that there is no need for a balance control on the front panel — the CP-1 does all necessary balancing automatically.

Pro-Logic decoders are currently very expensive. To this, between four and eight channels of amplification must be added together with the appropriate number of loudspeakers

The total outlay to get one of these systems up and running is thus considerable. The best of them produces astoundingly realistic effects from Dolby Stereo encoded material. Even the cheapest of the Dolby Surround decoders improves sound quality significantly. In addition to Dolby Surround or Pro-Logic modes, most decoders also offer processing modes to deal with mono and stereo material that is not encoded in Dolby Stereo.

Lucrative Sounds

While basic Dolby Surround processors are falling in price to the point where they will undoubtedly enter the mainstream hi-fi market, Pro-Logic processors are still something of a toy for the wealthy. Judging by the activity in the whole surround sound area, the manufacturers believe that there is a demand for it.

Most of us have bought our video recorders and compact disc players and the industry must look for growth elsewhere — such as satellite television, CD-video and now surround sound. Surround sound could be a lucrative area for the industry, because sales of processors not only creates a new market in itself, but it also boosts sales of amplifiers and loudspeakers to deal with the extra audio channels involved. ■

FEATURE

Personal Cassette Amplifier

A budget-priced 2W amplifier adds a speaker to cassette players.

R. S. Powell

Many car owners like to listen to music of some form while driving, be it from a car radio or cassette. Unfortunately car cassette players are either expensive or unreliable and tend to attract thieves. This article describes the construction of a simple little amplifier which may be used with a personal cassette player to enable tapes to be played in the car.

An amplifier of this type can be easily hidden, and the cassette player may be removed when one leaves the car. This simple system offers a low cost solution to providing in-car music with the added advantage that personal cassette units are less renowned for damaging tapes than cheap car players.

The amplifier can of course be used in a wide variety of other applications.

The Amplifier

The basic circuit for the amplifier is shown in Fig. 1. This may be used in either of two ways:

1) The circuit may be used with two resistors connected to the amplifier input — one to each channel of the stereo output from the player, as shown in Fig. 1; alternatively,

2) Two of the circuits may be used to provide stereo by omitting R1 from each amplifier and connecting one circuit to each output channel. A dual-gang potentiometer should then be used for the volume control.

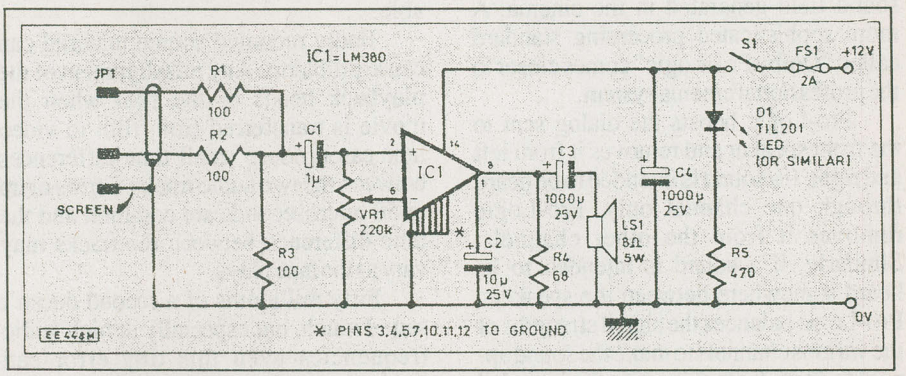
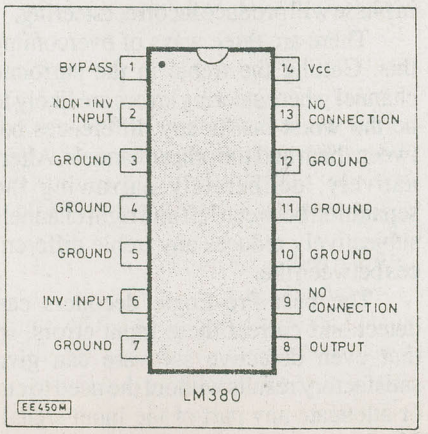


Fig. 1. Complete circuit diagram for the Personal Cassette Amplifier and below, pinout of the LM386 power amp IC.



Circuit

The LM380 will deliver about 2 Watts into an eight ohm speaker, which is perfectly adequate for reasonable volume levels, even at highway speeds. The actual circuit is very simple; R1, R2 and R3 constitute a passive mixer, forming a single signal from the left and right channels. As the headphone output usually matches impedances between 32 ohms and 11 kilohms, values of 100 have been chosen

Parts List

Resistors

R1 .....(see text)
R2,R3 100
All 1/4W, 5%

Potentiometer

VR1 .....220K log. (see text)

Capacitors

C1 .....1u tantalum
C2 .....10u elect. 25V
C3,C4 .....1,000u elect. 25V

Semiconductors

D1 .....TIL201 LED (or similar)
IC1 .....LM380 amplifier

Miscellaneous

JP1 .....stereo jack plug
FS1 ..... 2A inline fuse and holder
LS1 ..... 8 ohm 5W speaker
Veroboard, 16 strips by 28 holes, shielded stereo lead, connecting wire, etc.

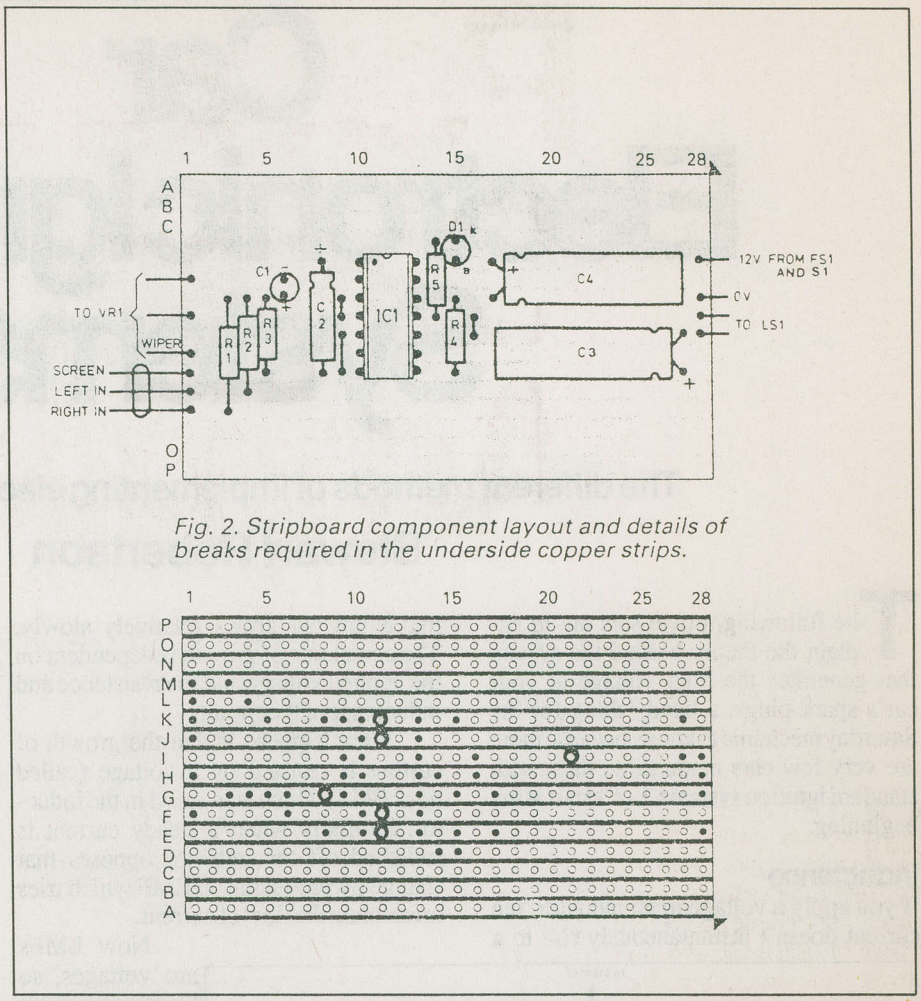


Fig. 2. Stripboard component layout and details of breaks required in the underside copper strips.

for R1 to R3. The signal developed across R3 is amplified by the LM380. VR1 varies how much signal is sent to the inverting input and hence determines the gain. The output is fed to the speaker via the capacitor C3.

One should note C2 and R4 which are different from values usually used with the LM380. R4 helps prevent distortion and replaces the usual Zobel network, while C2 has been increased to 10u for the same reason.

Capacitor C4 is a decoupling capacitor and should be 1000u or more to stabilize the supply for the amplifier. The circuit will run from the car battery (or any other DC supply of 12 to 18V at about 500mA) and an LED indicates when the circuit is turned on. A short length of shielded cable should be used to link the amplifier input to a jack plug for the headphone socket on the cassette unit.

Construction

The unit is easily constructed on Veroboard as shown in Fig. 2. Note that pins 3, 4, 5, 7, 10, 11 and 12 of the LM380 are all grounded to help form a heatsink for this IC. For stereo, two such boards may be produced, omitting R1 from each. Take care to solder the capacitors the correct way around, and for the inexperienced constructor the use of an IC socket is recommended.

A reasonable length of shielded cable should be connected to the amplifier and terminated in a stereo 3.5mm plug suitable for the cassette unit in use. The only controls are the on/off switch and volume control, along with the on indicator LED if this is required. Remember the circuit should be powered via an in- line fuse as with all electrical circuits in the car. A two amp fuse as normally used with a car radio will do.

When fitting the unit into the car take care to check if the speaker(s) are grounded and if so which lead. The unit may be mounted in a plastic box, or, for example, in a console unit within the car. The author's unit is mounted behind the car-radio blanking cover along with an LCD clock unit. From the outside there is no visual indication of any audio apparatus within the car which is ideal in helping prevent would-be thieves from even attempting to enter the car.

Using the Amplifier

Once the amplifier has been fitted into the car, a small bracket to hold the cassette unit can be made by bending the end of a short length of metal rod and screwing this against a flat surface in the car. The author's unit mounts nicely on the car console.

The cassette player may be powered by ordinary batteries but a good alternative is to use rechargeable nickel cadmium cells. These rechargeable batteries are adequate for even long journeys. If one is concerned at the idea of the batteries running flat in the middle of a tape a simple circuit may be built to power the unit form the car battery using an LM317M. Details of such a circuit are readily available most suppliers catalogs give details. ■

Fig. 2. Stripboard component layout and details of breaks required in the underside copper strips.

FEATURE

Car Electronic Ignition Systems

The different methods of implementing electronic ignition.

Stewart Robertson

The following article sets out to explain the theory behind the system that generates the high voltage at your car's spark plugs, a handy thing for the Saturday mechanic to know, because there are very few cars made these days with standard ignition systems. Let's start at the beginning.

Inductance

If you apply a voltage to an inductor, the current doesn't instantaneously rise to a maximum but grows relatively slowly. The actual rate of growth is dependent on the applied voltage and the resistance and inductance of the circuit.

What happens is that the growth of current is resisted by a voltage (called *back EMF*) which is induced in the inductor. Similarly when a steady current is switched off the inductor opposes that change by producing an EMF which tries to maintain the flow of current.

Now EMFs are voltages, so by getting current to flow through a coil and then switching the current off we can generate a voltage. Which if the inductance is large the resistance low and the rate of switch-off quick can be quite a high voltage.

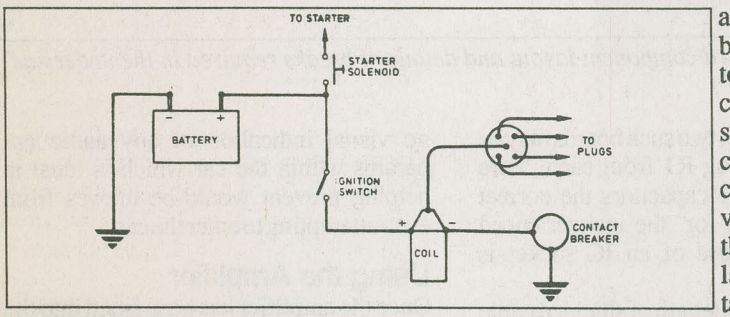


Fig. 1b. Conventional system with an in-circuit current-limiting ballast resistor.

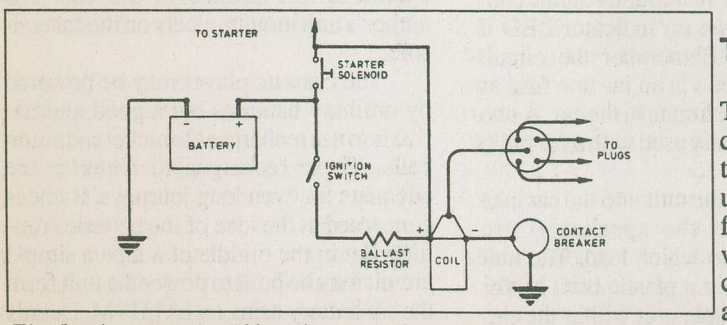


Fig. 1a. A conventional breaker ignition system.

Transformers

This high voltage can be stepped up to say 40kV if we use the transformer action by winding another coil of many turns around the inductor. This is essentially the action of a *coil* in a conventional ignition system.

The current is switched on and off by the contact breaker points in the distributor. The rotor arm and distributor cap are used to direct the high voltage to the correct spark plug. See Fig. 1.

How It Works

Let's just go over the circuit in case we have to find any faults in it. The source of supply is the car battery which, by a heavy duty cable, normally connects to the starter solenoid. The solenoid terminal is used to feed current to the ignition switch, which in turn feeds the coil positive (+) terminal.

Current flows to ground (car chassis) through the coil if the contact breaker points are closed. When the points open a high voltage is induced and there is a capacitor connected across the points to reduce arcing and enhance the effect.

High voltages leave the coil by the thick lead (lots of insulation) which goes to the distributor. Typical coil primary resistance is three ohms and maximum current in the region of four amps.

This system is called the *Kettering* system after Charles Kettering who invented it. It works OK, provided that the spark is made to occur when the respective cylinder is just before-top-dead- center (BTDC). This can usually be adjusted by rotating the distributor in its mounting and is called *timing* the ignition.

Spark Advance Systems

Unfortunately there are some mechanical add-ons to enhance performance (anything mechanical is unfortunate). One of these add-ons is to advance the spark so

that it occurs earlier at high engine revolutions.

This is known as the *centrifugal advance system* and is a quaint collection of bob weights and springs buried in the bottom of the distributor. As the revs increase it rotates the cam of the contact breaker points a few degrees in the direction of rotation, and so the spark occurs earlier.

Similarly the base plate is rotated by another system which advances the spark only on light throttle openings. This is an economy device which is activated by a vacuum capsule on the side of the distributor.

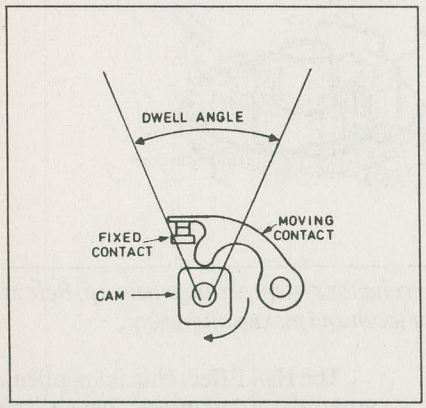


Fig. 2. Dwell angle or dwell time is the period that the contacts are closed.

Limitations

The Contact Breaker systems was invented by Charles Kettering in 1908. Although he was undoubtedly a far-seeing man (he later became head of General Motors) it is not surprising that we are now able to improve on his invention.

The areas in most need of improvement are to be found in the low voltage section of the distributor.

Points

The points are a switch which when closed allows current to flow in the coil. The size of the voltage that is generated by the coil is directly proportional to the *speed* that the points open and the *amount* of current that the coil carries.

Both speed and amount of current are limited by the size of the points set. A large set could carry more current but would not open so quickly or alternatively a small set would open quickly but no be able to carry the current. A modern points set is a compromise.

Dwell

The time that the coil has to store energy is determined by the time the points are closed and is known as the *dwell time*. At high engine speeds the dwell time is very short and can become inadequate leading to misfiring and certainly to inadequate combustion and loss of power and economy. This occurs because the dwell time is controlled by a fixed dwell angle of cam rotation. See Fig. 2.

Maintenance

Arcing at the points surface erodes the metal and adjustment is lost. The cam follower also wears and contributes to loss of gap.

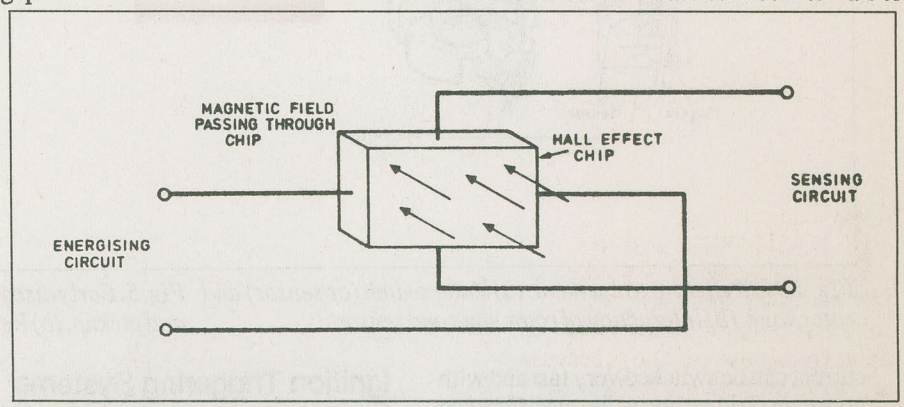


Fig. 3. Basic action of the Hall device. A magnetic field from a magnet is broken by a rotating disk and induces an energizing pulse in the device.

Adequate gap to prevent arcing and maintain dwell angle is gradually lost and needs to be restored every 5,000 miles or so. If emissions and economy are to be maintained even more frequently adjustment is called for.

Timing

All timing operations are controlled mechanically. They are therefore subject to friction, wear and general lack of accuracy. Low emission, high performance and good economy all rely upon accurate timing.

C.B. Ignition Enhancements

Ballast Resistor

The current carried by the coil is forced through by the voltage applied by the battery. Unfortunately, when cranking from cold the battery does not provide as high a voltage. A solution is to provide a coil which has a resistance of only 1.5ohm so that at the reduced voltage it will still draw about 4A of current.

However, when the engine is running, 12V to 14V will be available and so an extra resistance (*ballast resistor*) is connected into the circuit to limit the current to the 4A required. See Fig. 1b. This systems aids starting.

Sliding Points

When the points arc, they are eroded; if the arcing can be spread over a larger area it will take longer to erode the points and service intervals can be extended. The more recent Minis have an example of how to achieve this.

A *the points open the base plate and cam follower are arranged so that the points surfaces slide across each other and spread the erosion over a greater area. This is claimed to increase service intervals to 12,000 miles.

Transistor Assisted Ignition

So far in our view of ignition systems it's implied that the improvements have been to increase the maintenance period and improve economy. But now there is an even greater pressure on the manufacturers to reduce emissions. Rich mixtures of fuel and air produce a lot of nasty by-products but they do ignite easily. Modern engines run on lean mixtures — some very lean indeed.

To make sure the air/fuel mixture ignites properly it requires a high energy spark and a high voltage. The ordinary C.B. ignition systems are not always able to manage this, particularly at high engine speeds, so transistor assisted systems were introduced.

The energy stored in a coil is equal to $1/2LI^2$ where L = the inductance and I = current. It is clear that if the current is doubled the energy available is four fold. Unfortunately the points are already over burdened — if they were made larger to carry more current they would have too much inertia to handle the revs.

But by the use of transistors (usually a Darlington Pair) large currents can be controlled quite easily and additionally the

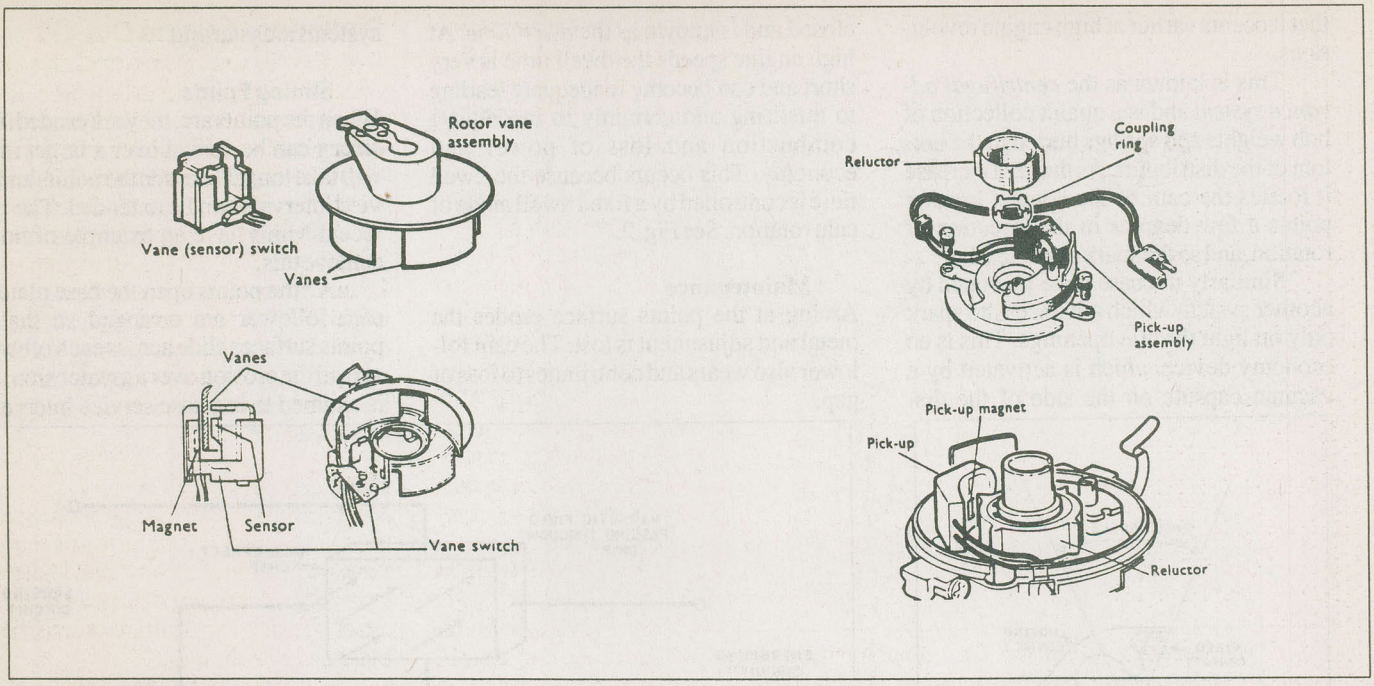


Fig. 4. Hall effect arrangement. (a) Vane switch (or sensor) and rotor vane. (b) Interaction of rotor vane and sensor.

Fig. 5. Early distributor reluctor system arrangement. (a) Releuctor and pickup, (b) Reluctor tooth and pickup alignment.

current can be switched very fast and with no arcing. Triggering of the transistors can be by contact breaker points or by some device which requires less maintenance.

Advantages

Large currents mean high energy, similarly fast switching speeds mean high voltage generation — this gives reliable firing when cranking and at high engine speeds. Dwell angle is less critical. Points sets, if used, carry only small currents and therefore last longer without adjustment.

Switching is clean, no arcing, so timing is more accurate. Also the effects of points bounce can be eliminated which ensures more accurate timing.

Overall the result is a car which starts more reliably, produces more power and is more drivable when cold and needs less choke. This is bound to improve emissions and fuel economy.

How To Recognize

This type of system has now been superseded but was normally housed in a module attached to the side of the distributor or attached to the coil. The coils have a low primary resistance of about three-quarters of an ohm.

Any system which is electronic but still uses the points is likely to be of this type. The modules are commonly called "amplifiers" or "igniters".

Ignition Triggering Systems

Contact points are mechanical switches; because they are mechanical they wear and need regular adjustment. They also bounce when they open and close at high speed, this can affect the accuracy of their timing.

Alternatives

With transistor ignition systems it is no longer necessary to rely on the points to perform the triggering function. With only a little more circuitry it is possible to trigger them with sensors which have no moving parts.

Early systems sometimes used photo-electric light sensors which produced a pulse when masked from a light source by a revolving disc. These were perfectly satisfactory but modern practice is to use a magnetic sensor and two systems now predominate.

Hall Effect

Modern semiconductor technology has produced a device which when placed in a magnetic field deflects an electric current and is called a *Hall Effect* device. See Fig. 3.

The actual arrangement is to fix a Hall Effect chip in a distributor so that a flanged disc rotating on the distributor shaft masks it from a magnet. Slots in the flange allow the magnetism to reach the Hall Effect device when the trigger pulse is required.

The Hall Effect chip is supplied with current and at the correct moment a trigger pulse appears on the output connection which is fed to the control module. No adjustment should ever be required. See Fig. 4.

Reluctor Systems

When a magnetic circuit is broken any coil in that circuit will experience an induced voltage. This voltage can be used to rigger a transistor ignition system. If a toothed wheel is part of the magnetic circuit then the circuit will be interrupted when a tooth is not in alignment with a pole piece.

An early method was to put the toothed wheel into a distributor and this has that advantage of being able to utilize the centrifugal advance and the vacuum advance systems. The advantages are that distributor bearing wear, gear backlash and the mechanical advance systems still produce some inaccuracy. See Fig. 5.

A more recent method is to put the toothed wheel on the flywheel there is no backlash or possibility of drive gear wear. Additionally extra teeth can be provided so that engine speed can be sensed by the same sensor. However, alternative systems are then required to replace the vacuum and centrifugal advance. See Fig. 2.

Advantages

Accurate ignition timing from a no-main-

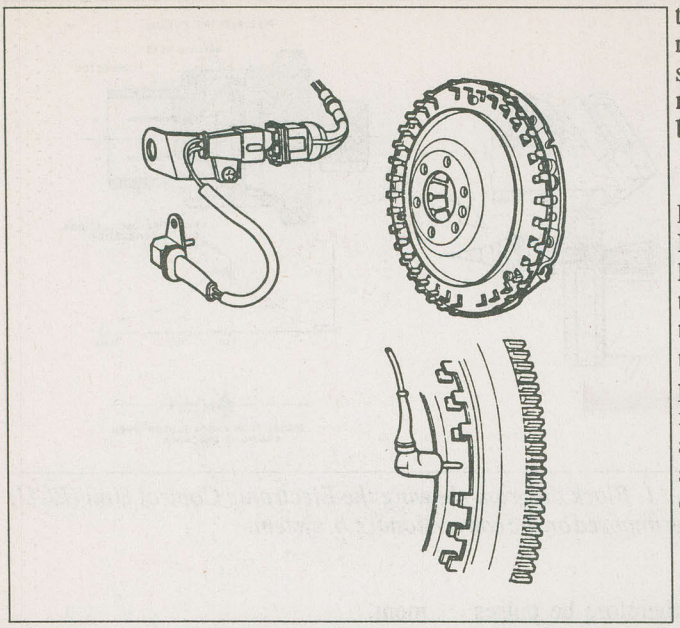


Fig. 6. Flywheel reluctor sensor. This comprises a magnet with a projecting pole piece and a reluctor disk on the flywheel.

tenance system once set should not need adjustment.

Constant Energy Ignition

It takes time between each spark for the current and hence the magnetic field in the coil to grow to its maximum. If the coil does not reach full capacity it will not generate its full output and will be unable to ignite weak mixtures and misfiring can occur.

Certainly incomplete combustion leading to poor power and high emissions do occur. This is particularly the case with high reving engines and 6, 8 and 12 cylinder units.

There are numerous solutions to this problem but because electronics are relatively cheap it is common to find combined systems. The commonest are described below:

Electronic Dwell Control

Dwell period is related to the angle that the cam in the distributor rotates through while the points are closed. This is called the dwell angle and is usually about 50 degrees on a contact breaker system (see Fig. 2).

If dwell angle is increased at high revs, there will be an increase in dwell *period* compared with a fixed dwell angle system. This is easy to arrange if electronic triggering is in use. The increased period allows the coil time to reach its maximum current flow and hence maximum energy storage.

The reduced dwell at low revs, reduces current consumption and heating of the coil.

Constant Current Operation

With constant current operation the coil resistance is made so low (0.80 ohm) that the coil current rises to its maximum even in the short time available at high revs. The constant current circuitry prevents it from rising too high in the longer periods available at low revs.

Stationary Engine Cut-Off

Both the above systems employ a circuit which cuts off current to the coil when the engine is stationary. Tis is essential as otherwise the coil would overheat with the high current (as high as about 18A) which would flow if the ignition were left on.

These systems optimize the ignition system so that regardless of engine speed, battery voltage, starting or high revs, the engine is provided with a powerful and consistently timed spark. And yet at low revs, or when stationary, components are protected from excessive heat and power is not wasted.

How To Recognize

Most modular electronic ignition systems now incorporate all or some of the previously mentioned techniques. These systems are usually housed in packs which are attached to the side of distributors or on the bulkhead with the coil.

However, note they still use the mechanical vacuum and centrifugal advance mechanisms so there is still a distributor- like casing driven by the cambelt or camshaft. Only in the programmed ignition systems is the distributor eliminated (except for cap and rotor arm).

Programmed Ignition

Transistor ignition systems with a conventional distributor using centrifugal advance and vacuum advance do not completely meet the requirements of modern engines in modern environments.

Distributor systems sense engine load by the use of manifold depression. This is arranged to mechanically vary the rotation of the distributor. Apart from the usual difficulties associated with mechanical control systems such as fric-

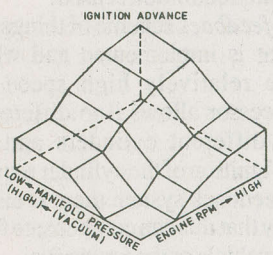


Fig. 7. Ignition or engine map using the distributor system.

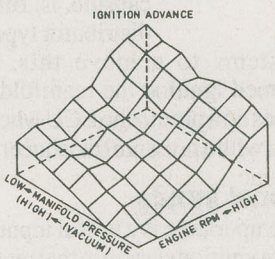


Fig. 8. Engine map using the programmed ignition system.

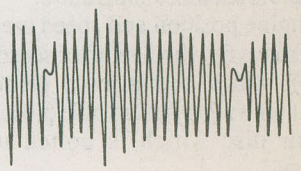


Fig. 9. Typical waveform to be expected from a reluctor sensor output.

tion, wear and backlash, there is a limitation in the range of different amounts of advance which can be accommodated. See Fig. 7.

Similarly centrifugal (bob weight) advance systems mentioned previously have all the mechanical disadvantages mentioned and can provide only tow stages of advance. Finally mechanical systems have no facility for the input of additional information such as engine temperature.

Microprocessor Ignition Control

Programmed ignition comes in the ubiquitous "black box" called an ECU (electronic control unit). It makes use of a ROM IC to store information about a particular engine's advance requirement under all load and speed conditions. In operation this is then read by a *microprocessor* and further modified by additional inputs such as coolant temperature and engine knocking ("pinking") to provide the optimum ignition advance.

The stored information called an engine *map*, is worked out by the engine manufacturer on an engine test bed (see Fig. 8). Even the most rudimentary programmed ignition system will require the following inputs: engine position, engine speed, manifold depression, battery voltage and coolant temperature.

Engine position and speed are often taken from a flywheel reluctor sensor (see Fig. 6), which comprises a permanent magnet with a projecting pole piece and a reluctor disc which is bolted to the flywheel.

The disc has pairs of lugs projecting at 10 degree intervals around the circumference. The sensor is mounted in such a way on the engine that as the flywheel rotates the pairs of lugs pass each side of the projecting pole piece. Thus for an instant at 10 degree intervals the sensor and the lugs form a magnetic circuit and also pulses are generated, their frequency indicating the speed of rotation of the engine.

However, at Top-Dead-Center (TDC) for cylinders 1 and 4 and at 180 degrees further round thus TDC for cylinders 2 and 3 there are pairs of lugs missing. There will therefore be pulses missing at these points and the ECU can thus detect TDC for the appropriate cylinders (see Fig. 9). In this way engine speed and position is passed to the ECU.

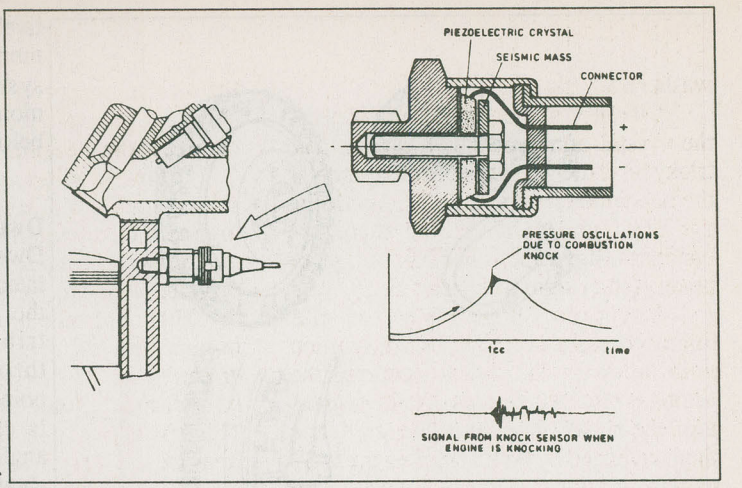


Fig. 11. Block diagram showing the Electronic Control Unit (ECU) superimposed on the conventional c.b. system.

Engine Load

Engine load is the other important parameter and this is related to manifold depression will hardly exist as the manifold will be at virtually atmospheric pressure. If on the other hand the car is descending a hill on a trailing throttle (no load) there will be a large vacuum or high manifold depression.

On light loads the engine runs much more economically if the ignition is advanced. You may recall that a vacuum capsule is fitted to distributor type ignition systems to achieve this. With programmed ignition the manifold pressure passes up a pipe to the ECU where it is measured with a pressure transducer.

Additional Inputs

Engine temperature is a useful input to include in an ignition system in that retarding of the timing can lead to better drivability from cold and speedier warm-up. A coolant sensor is already available on most cars anyway (for the temperature gauge) and so this is relatively cheap to implement.

Temperature sensors are made from a negative temperature coefficient semiconductor, encapsulated in a brass housing and screwed into the engine block or thermostat housing. Their resistance varies from about 10 kilohms at -10°C to about 300 ohms at engine running temperature.

Knock Sensor

A significant addition with programmed ignition is the *knock sensor*. Engines are more economical, more powerful and produce less harmful emissions if run at maximum advance.

In the past the standard setting always had to allow a margin for error because the consequences of an *over-advanced* engine are dire: broken pistons and burnt valves to name a couple. But with a microprocessor looking after the ignition it could run the engine at maximum safe advance and it could sense the onset of "knocking", "pinking" (or whatever you call it) it could then retard the ignition until the unwanted condition ceased.

This *feedback* scheme of things is exactly what is implemented and what is more the relatively high speed of a microprocessor allows it to differentiate between different cylinders and only retard the ignition of the cylinder required. Being a feedback system there is also the possibility that this can compensate for the age of the vehicle or the wrong fuel.

The knock sensor is a piezo electric accelerometer and is screwed into the block. The name belies a simple construction of a piezo crystal which is clamped between the block and a weight (ie. a thick

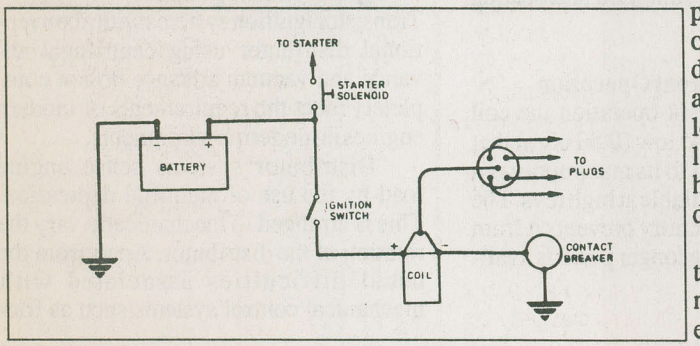


Fig. 10. Mechanical arrangement for the piezoelectric transducer knock sensor and examples of output waveforms. The sensor is mounted on the engine block.

washer). See Fig. 10.

Vibration of the engine thus squeezes the crystal and produces a signal. The tricky bit is then to sort out which signal is the one which indicates knocking. Inside the ECU you can imagine there are bandpass filters and other bits of jiggery pokery (sorry signal processing).

A typical algorithm for the microprocessor is: at the fourth ignition pulse after the knock has occurred the timing is retarded in steps of 1.25 degrees until the knock disappears. the ignition is then advanced by 0.625 degrees every 32 engine revs until the advance agrees with the figure in the ROM (read only memory) or the knock occurs again.

Programmed Ignition Advances

The advantages of programmed ignition are: better drivability, easier starting, smother running, improved economy and power, and automatic adjustment for the age of the vehicle. Additional inputs can be added to give traction control, smooth idle, smoothed auto gear change, turbo boost control and exhaust gas recirculation. Inter-connection with a fuel management system is also possible which enhances the effect of both systems.

How To Recognize

Apart from the rotor arm and distributor cap all the other functions of a distributor have been replaced by an electric control unit (ECU). The ECU is a box, often black, it has a finned section and apart from a multiplug has a vacuum pipe from the inlet manifold leading into it. It is often mounted on the bulkhead or suspension turret.

Fault-Finding

Both programmed ignition and the simpler module type ignition system are easy to fault find as long as you remember that thier function is to replace the contact breaker. Have a look at the diagram of the basic system (Fig. 1 and Fig. 11) and visualize the ECU in place of the contact breaker and ignore all the sensors.

Clearly a bulb connected across the two coil terminals should flash when the engine is cranked, if not then check for battery voltage from the coil all the way back to the battery. You should also find battery voltage on the coil negative with the engine stationary — due to "stationary engine cut-off" referred to earlier. If the test bulb still does not flash then it has to be the feed to the module or ECU which is often taken from the coil positive terminal or direct from the ignition switch.

If the car still does not star, *and assuming it is the ignition*, then it must be the high tension circuit. *A word of caution is due here: electronic ignition circuits produce quite a kick, so be careful.*

High tension circuits must be tested in such a way that you always provide an ground path. If you don't it'll find one of its own and do some damage on the way. The best check is to dive in the middle. Remove the lead to the center of the distributor cap and rest it on the engine in such a way that a spark can jump to the block. When cranking if you don't get a healthy spark which will jump across 1/4in. then you've got problems with the coil. If you have a spark then the fault must be in the distributor cap or rotor arm.

With a programmed ignition system the sensors can cause a problem. Obviously if the TDC sensor has failed the system will not function. Check out with a multimeter, reluctor coils have a resistance in the couple of hundred to three or four kilohms bracket. Failed ones are open circuit or short circuit.

Similarly with coolant temperature sensors, open or short. Good ones range from 10 kilohms when cold down to 300 ohms at 100°C. Hall Effect sensors are difficult but try your multimeter switched to AC volts on the output lead. With the engine cranking any reading probably means OK.

Poor Performance

Apart from tired components like plugs and leads poor performance can only be caused by bad timing, so with the module type of ignition check it and also check the operation of the vacuum and centrifugal advance systems.

Programmed ignition cannot get its ignition timing wrong except if it thinks the engine is cold so check out the coolant temperature sensor. The only other problem could be "pinking" and this points the finger at the knock sensor.

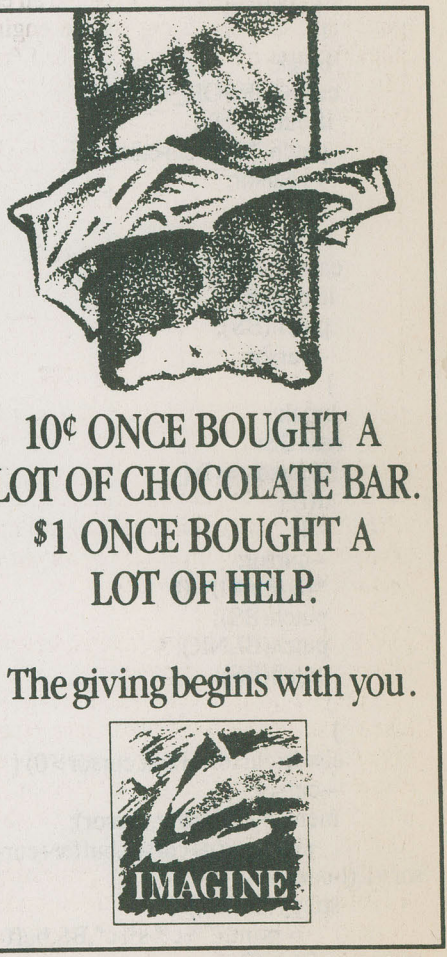
Incidentally, correct function of this component can be verified by tapping the engine block close to the sensor quite hard and repeatedly with a spanner. If the engine is ticking over at hot idle speed you will detect a drop in speed which indicates the timing has been retarded. However, some cars have a stepper motor controlling the idle speed so this will have to be disconnected first.

In Conclusion

We have purposely not attempted to explain the workings of the inside of "black boxes" found in the ignition system on cars. Nobody in their right mind is going to attempt to fix one of them at the side of the road.

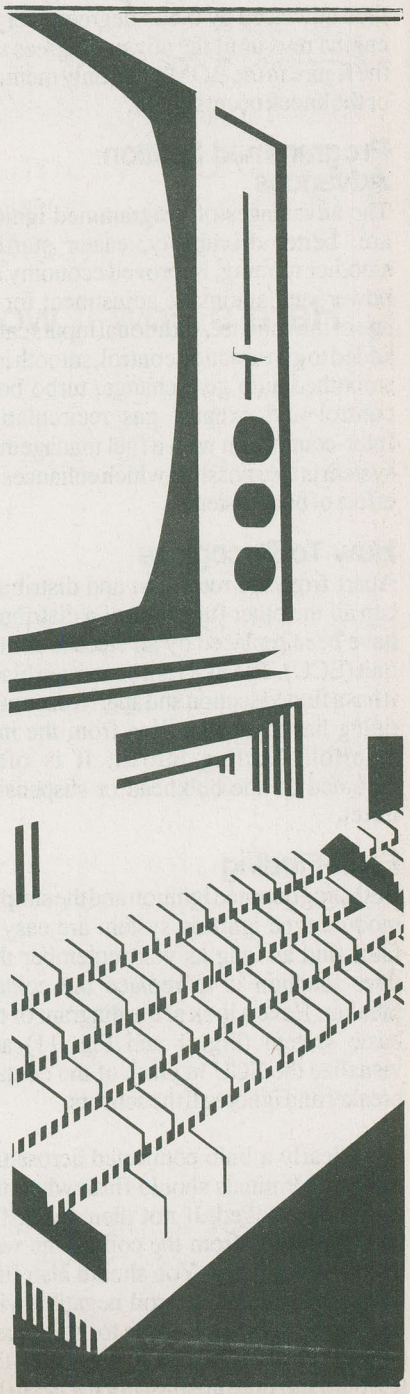
The guts of the ECUs however are very interesting and will perhaps be considered at a later date. What we have attempted to do is show that although sophisticated, these systems are quite easy to understand at the block diagram level and give enough, we hope, information to quickly resolve any problem associated with them.

Do please look before you leap — like any electrical device in the hostile environment of a car engine component — most faults are caused by poor connections.



continued from page 9


```
 while(i) {
  putch(BS);
  --i;
 }
 }
 break;
case INS:
 if(insert) {
  insert=0;
  small_cursor();
 }
 else {
  insert=1;
  big_cursor();
 }
 break;
case HOME:
 while(cursor) {
  putch(BS);
  --cursor;
 }
 break;
case END:
 while(cursor<l) {
  putch(*(buffer+cursor));
  ++cursor;
 }
 break;
case CURSOR_RIGHT:
 if(cursor<l) {
  putch(*(buffer+cursor));
  ++cursor;
 }
 break;
case CURSOR_LEFT:
 if(cursor) {
  putch(BS);
  --cursor;
 }
 break;
case BS:
 if(cursor==l) {
  if(l) {
   --l;
   --cursor;
   *(buffer+l)=0;
   putch(BS);
   putch(BLNK);
   putch(BS);
  }
 }
 else if(cursor<l&&cursor>0) {
  --cursor;
  memcpy(p,buffer,cursor);
    memcpy(p+cursor,buffer+cur-
sor+1,(l-cursor)+1);
  strcpy(buffer,p);
     i=printf("%c%s%c",BS,buff-
er+cursor,BLNK)-1;
  while(i) {
   putch(BS);
   --i;
  }
 }
 break;
case ESC:
 while(cursor<l) {
  putch(*(buffer+cursor));
  ++cursor;
 }
 while(l--) {
  putch(BS);
  putch(BLNK);
  putch(BS);
 }
 cursor=0;
 *buffer=0;
 break;
default:
 if(c>=0x20&&c<=0x7f) {
  if(cursor==l&&l<size) {
   *(buffer+l++)=c;
   *(buffer+l)=0;
   putch(c);
   ++cursor;
  }
  else if(cursor<l) {
   if(!insert) {
    *(buffer+cursor++)=c;
    putch(c);
   }
   else if(l<size) {
    memcpy(p,buffer,cursor);
    *(p+cursor)=c;
    memcpy(p+cursor+1,
     buffer+cursor,(l-cursor)+1);
    strcpy(buffer,p);
    i=printf("%s",buffer+cursor)-1;
    while(i--) putch(BS);
    ++cursor;
   }
  }
 }
 break;
 }
 } while(c!=CR);
free(p);
small_cursor();
return(strlen(buffer));
} else return(-1);
}

big_cursor()  /* make the cursor big
*/
{
 union REGS r;

 r.h.ah=15;
 int86(0x10,&r,&r);

 r.h.ah=1;
 r.h.cl=7;
 r.h.ch=3;
 int86(0x10,&r,&r);
}

small_cursor()  /* make the cursor
small*/
{
 union REGS r;

 r.h.ah=15;
 int86(0x10,&r,&r);
 r.h.ah=1;
 r.h.cl=6;
 r.h.ch=5;
 int86(0x10,&r,&r);
}
```



HOW TO GET MORE INFO

For more information on any of the companies advertised in this issue, use the Electronics & Technology Today Reader Service Card.

Here's how it works:

Each ad - and each product listed in the *For Your Information* and *New Products* sections - has a unique Reader Service Number.

Make a note of the number for each of the companies you are interested in...

You'll find the Reader Service Card bound into your copy of Electronics & TechnologyToday. Circle the appropriate numbers on the card, fill in the simple questionnaire (don't forget your own address!), and send it off.

A copy of your request is forwarded to each of the respective companies - who will be more than happy to respond to your interest by sending you a full information package.

Use our card to get the Whole Story

Electronics & Technology Today **READER SERVICE CARD**
May 1989

Card void 6 months after issue date

Circle the appropriate Reader Service number below for more information, the advertiser will send you further literature free of charge. PLEASE PRINT.

NAME: John Smith

TELEPHONE: (319) 591-7840

STREET: Mainstreet

CITY/TOWN Cityville

PROVINCE Alberta POSTAL CODE M4G-5A4

COMPANY NAME: ABC Design

JOB FUNCTION (CHECK ONE)

- ☑ Corporate Management
- ☐ Operational Management
- ☐ Computer Systems Management
- ☐ Financial Management
- ☐ Education
- ☐ Technology
- ☐ Consultant
- ☐ Marketing

TYPE OF INDUSTRY (CHECK ONE)

- ☐ Government
- ☐ Education
- ☐ Finance
- ☐ Computer Industry
- ☑ Construction
- ☐ Medical/Legal
- ☐ Manufacturing
- ☐ Other

I have recently purchased the following products after reading about them in Computing Now!:

SYSTEM 2000 / 386 $ 3000

$

Where product purchased

Do you subscribe to Computing Now! Yes ☑ No ☐

Complete below if you wish to take out a subscription:

- ☐ One year $22.95
- ☐ Two years $37.95
- ☐ Bill me (subscription will start once payment is received)
- ☐ I enclose my cheque (send with card in envelope)
- ☐ Visa ☐ MasterCard ☐ Amex

Card No Card Expiry Date

Circle the Reader Service Card Numbers for the items in which you are interested.

1	2	3	4	(5)	6	7	8	9	10	11	12	13	14	15	(16)	17	18	19	20
21	(22)	23	24	(25)	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
41	42	43	44	45	46	47	48	(49)	50	51	52	53	(54)	55	56	57	58	59	60
61	62	63	64	(65)	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100

FEATURE

Computer Logic Design Part 3

This month we'll begin to look at flip-flops, the beginning of memory logic. A fundamental area of computer design, memory and counting move into areas of logic without finite states.

Steve Rimmer

In the first two installments of this series we looked at the rudiments of finite state logic. In this sort of logic design, any arrangement of logical elements, however huge, complicated or badly solderered, will have a finite number of output states for a finite number of input states. Such a a logic array must be essentially static... it doesn't do anything until you change something at one of its inputs.

This month we're going to introduce a new element into logic design, this being the D flip flop. Flip flops have two states, just as do other logic elements, but their output states are dependant upon what happened to their inputs over time.

Remember This

A D flip flop has six connections. These are its input, its clear and preset lines, its clock line and its two outputs, Q and $\overline{Q}$. The state of Q will always be the compliment of the state of $\overline{Q}$.

The simplest function of a flip flop is to remember the state of its data input after the state has changed. If you set the data input either high or low and send a positive pulse to the clock input, the state of the input will appear at the Q output. It will remain there after the clock pulse has gone, and it will remain even if the data input changes.

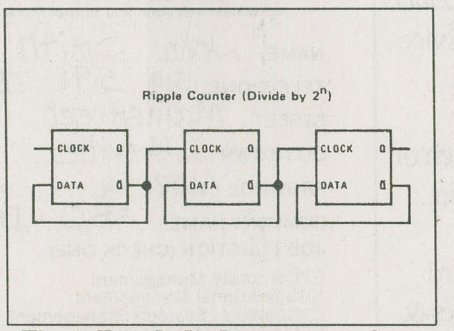


Fig. 1. Type D flipflops connected as a ripple counter.

All by itself, one flip flop is not terribly useful, but they have all sorts of applications when they get together and gang up on logic design problems.

Figure One illustrates a D flip flop "ripple" counter, or binary divider. This will divide the frequency of the pulses at the leftmost clock input by 2 raised to the power of the number of flip flops in the counter.

Figure Two illustrates a shift register. This is probably a more useful example of what flip flops do. Let's assume that there's a high state at the input to the shift register to begin with. The first time a clock pulse is applied to the common clock line, the high state will appear at the Q output of the first flip flop. The next time a clock pulse occurs, it will appear at the Q output of the next flip flop, and so on. With each successive clock pulse the initial state... the data... will shift itself one stage further along in the circuit.

The ripple counter in figure one can be thought of as a frequency divider, but it's really a binary counter. If you regard the Q outputs of the three flip flops as being bits, it will cycle through the binary numbers from zero through seven as pulses are applied to its input. The leftmost flip flop represents the lowest order bit. If you were to add more flip flops to the circuit, it would count up to larger numbers before wrapping back to zero.

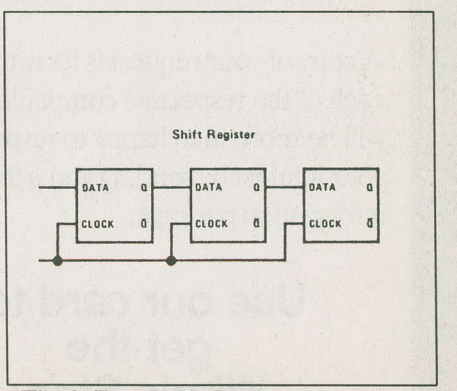


Fig. 2. Type D flipflopds connected as a shift register.

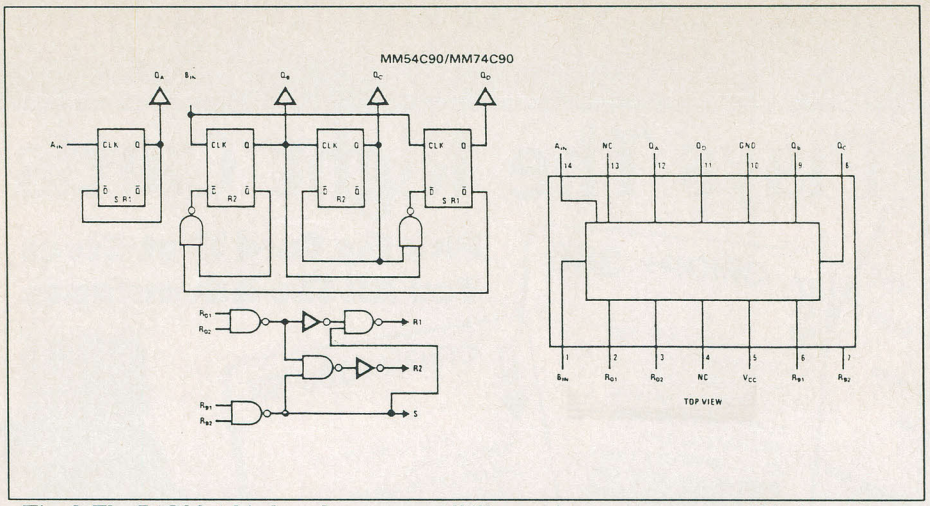


Fig. 3. The 74C90 4-bit decade counter. All illustrations are courtesy of National Semiconductor.

Count to Ten

Computers think in numbers which are even powers of two. People like to think in numbers which are even powers of ten. Ten is really a very troublesome number to use as a base, and it's only our finger count which has prompted us to settle on it.

In designing computer circuitry, we invariably use the numbers which best suit computers. However, specialized logic circuits which are to be used by people often require some consideration of their numerical preferences. In these cases, it's useful to know how to make a circuit which wants to count up to sixteen behave itself and count to ten.

A four stage binary counter will have sixteen output states, that is, sixteen possible values represented by the four Q outputs of its flip flops. Of these, the ones representing zero through nine are of interest in a circuit which will count to ten. If you wanted to build a frequency counter, for example, you'd only want to count to ten for each decade.

The problem, then, is to make the sixteen state counter stop at ten and wrap itself back to zero. The problem is very simple, but it requires that we use an as yet undiscussed line of the flip flops. If you pulse the clear line of a flip flop low, the flip flop will forget whatever its has been told previously. The Q output will go low and the $\overline{Q}$ output will go high. The flip flop will go to its natural quiescent state. The preset line will do just the opposite.

In a four bit counter, clearing all four flip flops will set the output of the counter to zero. It would seem that in order to make the counter count to nine and then reset itself to zero, all we need do is to hit the clear line on the tenth input pulse.

In order to detect the tenth pulse, we must watch the output of the counter with an array gates to detect the binary number ten. This number is

1010

in binary, that is, eight plus two.

Figure Three illustrates a commercial decade counter. You can see how its four flips are gated in order to make them reset when they reach a value of ten.

The clear pulse for this counter also represents the input pulse for the next counter if you want to count to numbers larger than nine. If you were to place a second counter beside the first one, with its input being the clear pulses from the first counter... inverted, in this case... its value would be the tens in the number being counted. You can add as many decades as you need to count to the number you have in mind.

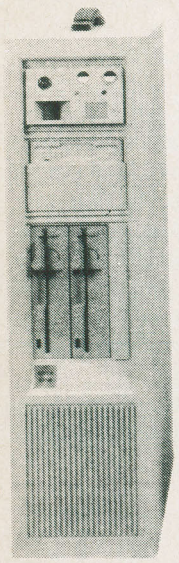
We'll look at some practical applications of flip flops in the next installment of this series. ■

Circle No. 131 on Reader Service Card

ORION ELECTRONICS SUPPLIES INC.

IMPORTERS & DISTRIBUTORS — INDUSTRIAL — COMMERCIAL — EDUCATIONAL — SALES & SERVICE

A Sure Winner: Plays The Right Cards



Pick the Card That Gives You All The Advantages

A ♥ THE BLAZING ORION 25MHZ CACHE 386 TAKES YOU TO THE LIMIT

SAME SPECS AS SYSTEM 386 BUT WITH: OUR 25MHz CACHE 386 MB
32 KB CACHE MEMORY
8 KB CACHE AUTO BOOTING ROM
PGA SOCKET FOR 80387-25
8 EXPANSION SLOTS
EMS VER 4.0 DRIVER
1/O CACHE UTILITY DIAGNOSTIC PROG
FULLY COMP WITH MS DOS; OS/2; UNIX; CONCURRENT DOS 386; PC DOS/386; XENIX; ETC;

$2,495

K ♥ ORION 386

TURBO 8/20 MHz
INTEL 80386-20 CPU
1MB RAM EXP 4/8 MB
1.2 MB OR 1.4 MB DRIVE
FLOPPY/HARD DISK CONT.
SER/PAR/GAME/CLOCK
AT 101 ENHANCED KEYBOARD
COLOR OR MONO VIDEO CARD
ASSEMBLED & FULLY TESTED IN CANADA
100% IBM COMPATIBILITY

$1,595

386-25... $1,795

Q ♥ ORION 386 SX

INTEL 80386 SX CPU
TURBO 8/16 MHz
1MB RAM EXP TO 4/8 MB
1.2 MB OR 1.4 MB DRIVE
FLOPPY/HARD DISK CONT.
SER/PAR/GAME/CLOCK
AT 101 ENHANCED KEYBOARD
COLOR OR MONO VIDEO CARD
ASSEMBLED & FULLY TESTED IN CANADA
100% IBM COMPATIBILITY

$1,195

J ♥ ORION 286

TURBO 6/12 MHz
1Mg RAM EXP TO 4MB
INTEL 80286 CPU
1.2 MB OR 1.4 MB DRIVE
FLOPPY/HARD DISK CONT.
SER/PAR/GAME/CLOCK
AT 101 ENHANCED KEYBOARD
COLOR OR MONO VIDEO CARD
ASSEMBLED & FULLY TESTED IN CANADA
100% IBM COMPATIBILITY

$899

286-16... $999

10 ♥ ORION 88

8 EXPANSION SLOTS
640K RAM
SWITCHABLE TURBO
360K OR 720K DRIVE
SER/PAR/GAME/CLOCK
MONO/COLOR VIDEO CARD
AT STYLE CASE & KEYBOARD
ASSEMBLED & FULLY TESTED IN CANADA
48 HOURS BURN IN
100% IBM COMPATIBILITY

499

XT 12MH - $549
XT16 - $599

STOP!

You can't find a better deal than this: With ORION the odds are with you so there's no need to gamble ORION cards are marked! Marked by superior design; quality manufacturing & loaded with features at prices that will make the competition fold!!! FOR A SURE BET GO WITH ORION

and compare our quality and prices! Before You Purchase *ANY* Computer!

ORION DISKETTES

100% ERROR FREE & LIFETIME WARRANTY

KAO DIDAK

KAO 5¼" DISKS	PER BOX	10 BOXES
MD2D 360K	$ 8.49	$ 7.95
MD2H 1.2M	$11.45	$10.95
FOR COLOR ADD	$ 3.00	$ 2.75
KAO 3½" DISKS	PER BOX	10 BOXES
MF2DD	$14.95	$13.95
MF2HD	$28.95	$27.95
FOR COLOR ADD	$ 4.00	$ 3.75
DISCAROO COLOR IN POUCH	19.95 $22.95	18.95 $19.95

ORION

ORION 5¼" DISKS	PER BOX	10 BOXES
OD2D 360K	$ 6.99	$ 6.49
OD2HD 1.2M	$10.95	$ 9.95
FOR COLOR ADD	$ 3.00	$ 2.50
ORION 3½" DISKS	PER BOX	10 BOXES
OF2DD 1 MEG	$12.95	$11.95
OF2HD 2 MEG	$24.95	$22.50
FOR COLOR ADD	$ 4.00	$ 3.50

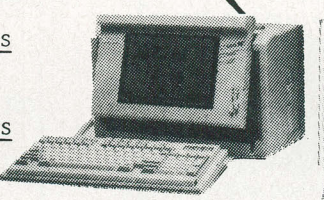
SONY

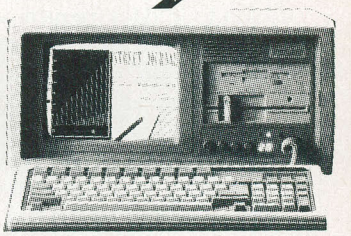
5¼" DSDD 360K....$ 9.95
W/PLASTIC CASE...$10.95

	PER BOX	10 BOXES
3½" DSDD 1M.....	$18.95	$17.95
3½" HD 2M	$34.95	$32.95
5¼" HD 1.2M.....	$18.95	$17.95

NO NAME DISKETTES

NO NAME 5¼" DISKS	PER BOX	10 BOXES
NND2D 360K	$ 4.99	$ 4.49
NN2HD 1.2M	$ 9.95	$ 8.95
NO NAME 3½" DISKS	PER BOX	10 BOXES
NNF2DD 1M	$10.95	$ 9.95
NNF2HD 2M	$21.99	$20.99





ORION PORTABLE SYSTEMS

	88 256K	286 512K	386 1 MEG	386 25MHz CACHE
9" AMBER DUAL CRT	1,195	1,695	2,495	3,695
9" EGA MONITOR	2,195	2,595	3,395	4,595
LCD 600X400 SCRN	1,595	1,995	2,795	3,995
PLASMA 600X400 S	2,495	2,895	3,695	4,895

Quality, Reliability and Service

MOST ORDERS SHIPPED WITHIN 24 HOURS. **SERVING YOU FOR OVER 15 YEARS** **If you find a better price call us before you buy.**

40 LANCASTER ST., W.
KITCHENER, ONT. N2H 4S9
PH: (519) 576-9902
FAX: (519) 576-9028

Credit card charges are not submitted until time of shipment

WHY WAIT? CALL ORION ELECTRONICS NOW!
ORDER TOLL FREE
1-800-265-2658

VISA MasterCard

Order desk & technical support open:
9.00 a.m. to 6.00 p.m. Monday - Friday
9.00 a.m. to 5.00 p.m. Saturday

For Service CALL
1-519-576-9026

ORION ELECTRONICS SUPPLIES INC.

IMPORTERS & DISTRIBUTORS — INDUSTRIAL — COMMERCIAL — EDUCATIONAL — SALES & SERVICE

SEAGATE ST-225-20 MB HARD DISK SYSTEM Includes hard disk controller, cables and instructions. All drives are pre-tested and come with a one year warranty. **$349**

Your #1 Source For Quality Computer Components — **Quality, Reliability and Service**

Seagate Hard Drives

ST225 KIT, 20MB, 65MS, (MFM)..$349.95
ST238R KIT, 30MB, 65MS, (RLL) $389.95
ST251-1, 40MB, 28MS, (MFM)....$475.95
ST 296 N 85MB 28MS (SCSI)....$799.95
ST4096, 80MB, 28MS, (MFM).....$849.95

SEAGATE 3½" DISK DRIVES
ST125, 20MB, 40MS, (MFM).....$375.95
ST138M, 32MB, 40MS, (MFM).....$479.95
ST138N, 32MB, 40MS, (SCSI)....$529.95
ST138R, 32MB, 40MS, (RLL).....$449.95
ST157R, 50MB, 40MS, (RLL).....$479.95

MiniScribe Hard Drives

MINISCRIBE 1 YEAR WARRANTY
3053 - 5¼", 40MB, 25 MS.....$575.95
3085 - 5¼", 70MB, 22 MS.....$799.95
3650 - 5¼", 40MB, 61 MS.....$399.95
8425 - 3½", 20MB, 68 MS.....$325.95
8438 - 3½", 30MB, 68 MS, RAL..$349.95

STAR HARD CARDS

SC20A, 20MB,65MS, MFM, XT, PS/2, 30 $495.95
SC20B, 20MB,62MS, MFM, XT, PS/2, 30 $475.95
SC125, 20MB,40MS, MFM, XT, PS/2, 30 $495.95
SC30A, 30MB,65MS, RLL, XT, PS/2, 30 $599.95
SC30B, 30MB,62MS, RLL, XT, PS/2, 30 $549.95
SC138M, 30MB,40MS,MFM, XT, PS/2, 30 $579.95
SC138R, 30MB,40MS,RLL, XT, PS/2, 30 $549.95

WESTERN DIGITAL Controller Boards

WESTERN DIGITAL HARD DRIVE CONTROLLERS
HARD DISK 20 MEG (MFM), XT.....$ 79.95
HARD DISK (MFM), XT.....$ 84.95
HARD DISK (RLL), XT.....$ 84.95
6 - 12MHz, HD (MFM), AT, XT286 $129.95
6 - 12MHz, HD/FD (MFM) AT, XT 286$139.95
6 - 12MHz, HD (RLL), AT, XT286 $165.95
6 - 12MHz, HD/FD (RLL) AT, XT 286$189.95
* ALL OF THE ABOVE ARE 2:1 INTERLEAVE *
16MHz, HARD DISK (MFM) AT, 386 $169.95
16MHz, HD/FD (MFM) AT, 386.....$189.95
16MHz, HARD DISK (RLL) AT, 386 $189.95
16MHz, HD/FD (RLL) AT, 386.....$199.95
16MHz, HD/FD ESDI INTERFACE AT, 386$299.95
* ALL OF THE ABOVE ARE 1:1 INTERLEAVE *

Floppy Controller Boards

AT XT FLOPPY DRIVE CONTROLLER
XT FLOPPY CONTROLLER.....$ 39.95
AT/XT HI DENS 360/1.2/720/1.44 $ 59.95

WE CARRY A HUGE SELECTION OF HARD DRIVE CONTROLLERS. ASK FOR A COMPLETE LISTING.

JOYSTICKS
GRAVIS (CAN MADE 1 YR WAR)....$49.95
GRAVIS (SAME AS ABOVE BUT CLEAR)...$54.95
IBM COMPATIBLE JOYSTICK FROM..$19.95
QUICK SHOT IBM/APPLE.....$29.95
TJ810 PERFECT MICRO IBM/APPLE $34.95
DELUXE JOYSTICK IBM/APPLE.....$39.95
WINNER 909 IBM/APPLE.....$34.95
COMPUTER JOYSTICK IBM.....$29.95
JOYSTICK 606 IBM.....$32.95

SCANNERS

HANDYSCANNER 2.5".....$ 299.95
HANDYSCANNER 4. 1/8".....$ 349.95
LOGITECH SCANNER 4.1/8".....$ 379.95
CAT IMAGE SCANNER.....$ 299.95
CHINON DESK SCANNER.....$ 895.95
SHAPE DESK SCANNER.....$1,295.95

EDIMAX LAN PROFESSIONAL
AL-2350 STAR TOPOLOGY ARC LINK..$189.95
AL-2351 BUS TOPOLOGY ARC LINK II $239.95
AH-2355 8 PORT ACTIVE HUB.....$489.95
AH-2356 4 PORT ARC LINK HUB.....$479.95
AH-2357 4 PORT PASSIVE HUB.....$ 39.95
EN-2360 ETHERNET NE-1000 COMP...$349.95
TM-500H 50 OHM TERMINATOR.....$ 8.95
TM-930H 93 OHM TERMINATOR.....$ 8.95

Floppy Drives

EPSON Panasonic

"YOUR CHOICE"
EPSON/FUJITSU
PANASONIC
5¼"360K...$ 99.95
5¼"1.2MB..$119.95
3½"720KB..$ 99.95
3½"1.44MB.$119.95
3½" DRIVES INCLUDE 5½" FRAMES

SONY 3M

DATA CARTRIDGES
DC2000...$34.95
DC1000...$29.95
DC600A...$42.95
DC600HC..$49.95
DC600XTD $49.95
DC300XLP $48.95
QD600A...$39.95
QD2000...$29.95
QD300XLP..$37.95
QD600XTD..$44.95

TTX MONITORS

1201A - 12" COMP AMBER MONOCH.....$129.95
1400F/A 14" TTL AMBER FLAT SCREEN $169.95
14S2F/W 14" VGA AN WHT FL SCREEN..$179.95
14S2F ANALOG/VGA PS2 COMPATIBLE...$199.95
1452 - .52 CGA 640 X 200.....$299.95
2410 - 14" RGB .43mm POL.....$389.95
2412AG .39 EGA 640 X 350 AG.....$479.95
2422 - 14" EGA .31mm A. GL.....$499.95
5439AG .39 VGA 640 X 480 AG.....$479.95
5432AG .29 VGA 720 X 480 AG.....$499.95
5436AG .28mm 1024 X 768 MULTISYNC $699.95
3435AG .31mm 800 X 600 MULTISYNC..$649.95
* ALL TTX MONITORS WITH TILT/SWIVEL BASE *

DataTrain Monitor

DC200S - 14".41mm DOT P. RGB T/S..$449.95
DC205S - 14".52mm DOT P. RGB T/S..$349.95
DC353S - 14".31mm EGA/CGA/T/S.....$499.95
DC355 DOT PITCH .41mm EGA/CGA.....$449.95
DC505 DOT PITCH .41mm VGA.....$499.95
DC600 M. RES VGA/DIG. D.P. .31mm..$599.95

DATA TRAIN MONITORS: MONOCHROME
V240A - 12" AMBER COMPOSITE.....$139.95
V242 - 12" TTL AMBER OR GREEN.....$134.95
V244 - 12" TTL, AMBER.....$129.95
V252 - 12" M. RES MONO AMB/GREEN..$149.95
V262A - 12" FLAT SCREEN TTL AMBER $159.95
V272 - 14" DUAL FREQ AMBER/WHT....$189.95
V282A - 14" FLAT SCR, DUAL FREQ...$169.95
V282W - 14" FLAT SCR, DUAL FREQ...$179.95
V502 - 12" ANLG VGA/MCGA MONO WH..$175.95

Modems — FAX MACHINES

1200 INTERNAL.....$ 74.95
1200 EXTERNAL.....$ 89.95
2400 INTERNAL.....$ 129.95
2400 EXTERNAL.....$ 139.95
4800.....$ 349.95
9600.....$ 799.95
ASHER FAX CARD 4800.....$ 499.95
ASHER FAX CARD 9600.....$ 895.95
PANAFAX UF150.....$1,495.95
PANAFAX UF250.....$2,295.95
PANAFAX UF140.....$1,395.95
PANAFAX UF260.....$2,999.95
RAVEN RF100.....$1,395.95

MICE

LOGITECH HI RES SERIAL.....$ 109.95
LOGITECH HI RES BUS.....$ 119.95
DEXXA 2 BUTTON AT, XT.....$ 59.95
DEXXA DELUXE AT, XT.....$ 69.95
GENIUS GM-6 PLUS 200 X 800 ...$ 69.95
GENIUS GM 6000 DELUXE PKGE....$ 89.95
JVC OPTICAL 250-500 DPI.....$ 99.95
MOUSE PAD.....$ 8.95
MOUSE STAGE.....$ 24.95

SPECIALTY INDUSTRIAL BOARDS FOR IBM COMPUTERS

SI-7210-C IEEE-488 CARD.....$369.95
SI-4SIP 4 SERIAL 1 PARALLEL $189.95
SI-8SIP 8 SERIAL 1 PARALLEL.....$249.95
SI-8520-X1 RS422 (PC/XT) 1 PORT $119.95
SI-8520-X2 RS422 (PC/XT) 2 PORT $139.95
SI-8520-A1 RS422 (PC/AT) 1 PORT $139.95
SI-8520-A2 RS422 (PC/AT) 2 PORT $179.95
SI-4232 CONVERTER(RS232-RS422)..$139.95
SI-7541 12 BIT AD/DA CARD.....$195.95
SI-8255 8255 I/O CARD.....$139.95
SI-2121 COPY BOARD.....$139.95

CLK 2900 2 SER/2 PAR FOR XT/AT..$ 69.95
CLK 3200 8 SER PORT PC XT/AT....$379.95
CLK 3300 MULTI USER CARD 4 PORT $129.95
CLK 3400 RS422 CARD XT/AT.....$119.95
CLK 3500 IEEE 488 CARD.....$329.95
CLK 3600 14 BIT A/D D/A CARD....$329.95
CLK 3700 12 BIT A/D D/A CARD....$199.95
CLK 3800 8255-8253 I/O CARD....$ 99.95

DATA SWITCH BOX MANUAL
RS232 SWITCH BOX 2 PORT $29.95
RS232 SWITCH BOX 4 PORT $39.95
CENTRONICS S/BOX 2 PORT $35.95
CENTRONICS S/BOX 4 PORT $45.95
SENDON UPS
UPS-250 XT OR SMALL AT..$475.95
UPS-400 FOR FULL SIZE AT $599.95
UPS-400 NO AVR.....$575.95
UPS-800 FOR 386.....$975.95
WITH NOVELL HOOK-UP $999.95

GENDER CHANGRS
25/15/9 M/M OR M/F.....$ 8.95
25-9 M/M OR F/F.....$ 8.95
JUMPERBOX DB25M/M F/F...$ 9.95
NULL MODEM.....$ 9.95
RS232 MINI TESTER M/F...$13.95
WIRING BOX DB25M/F.....$12.50
RS232 REVERSER.....$12.50
SURG PROTECTOR DB25M/F..$14.95
RS232 BREAKOUT BOX.....$69.95
MLP20 LOGIC MONITOR.....$69.95

Roland DG

PR9101 9-PIN 192 CPS DESKTOP....$ 279.95
PR9104 9-PIN 240 CPS DESKTOP....$ 349.95
PR2417 24-PIN DESKTOP.....$ 449.95
ROLAND DG PRINTERS
PR1215 216 CPS WIDE CARRIAGE....$ 579.95
PR1550 288 CPS WIDE CARRIAGE....$ 749.95
PR 2465 24 PIN WIDE .....$ 699.95
PR2017 17 CPA DAISY WHEEL.....$ 449.95
ROLAND LASER PRINTERS
LP1100 11 PG/MIN 512K.....$2,295.95
ROLAND FLATBED PLOTTERS
DXY1100 A/B SIZE 8-PEN HP COMP..$1,299.95
DXY1200 A/B SIZE ELECTROSTATIC..$1,795.95
DXY1300 A/B SIZE 1 MB BUFF STD $2,295.95
DPX2200 C-SIZE PEN LOGIC.....$5,985.95
DPX3300 D-SIZE FLATBED PRO.....$7,495.95
ROLAND ROLLERBED PLOTTERS
GRX300 D-SIZE ROLLERBED.....$5,495.95
GRX300M D-SIZE 1 MB RAM.....$5,985.95
GRX400 E-SIZE ROLLERBED.....$6,495.95
GRX400M E-SIZE 1 MB RAM $7,495.95

MANNESMANN TALLY

MT81 9-PIN 130 CPS.....$ 249.95
MT222 24-PIN 220/75 CPS.....$ 729.95
MT230-24 WIDE 300/150/100/75....$1,795.95
MT230-9 WIDE 300/150/100 9-PIN $1,395.95
MT905 LASER (HP SERIES II COMP) $1,899.95
1 MEG EXPANSION.....$ 499.95

Panasonic PRINTERS

EXP1180 11 192 CPS 9-PIN.....$ 299.95
EXP1191 11 240 CPS 9-PIN.....$ 375.95
EXP1124 11 192 CPS 24-PIN.....$ 475.95
EXP1524 16.5 240 CPS 24-PIN....$ 999.95
EXP4450 11 PPM LASER PRINTER....$2,795.95

EPSON A Printer For Any Application

24-PIN LETTER QUALITY DOT MATRIX PRINTERS
LQ-1050 264/220/88/73 CPS.....$1,095.95
LQ-2500 270/90 CPS DRAFT/NLQ....$1,295.95
LQ-500 180/60 CPS.....$ 429.95
LQ-510 180 CPS.....$ 529.95
LQ-850 264/220/88/73 CPS.....$ 895.95
LQ-950 24 PIN 2 X 12 DOT MATRIX $ 999.95
SQ-2500 540/180 INK JET 132 COL $1,495.95

LX-800 180/150 CPS.....$ 249.95
LX-810 180 CPS.....$ 299.95
EX-800 250/45 CPS.....$ 699.95
FX-1050 264/54 CPS.....$ 799.95
FX-850 265/54 CPS SMARTPARK...$ 599.95
FX-86E 200/40 CPS 80 CLMN....$ 499.95
DFX EPSON 533 CPS $2,895.95
JX-80 COLOR PRINTER.....$ 499.95

STAR MICRONICS PRINTERS

NX 1000 144/36 CPS.....$ 269.95
NX 1000C 144/36 CPS.....$ 289.95
NX 1000C 144/36 CPS (7 COLOR) $ 375.95
NX 1000 144/36 CPS (7 COLOR)..$ 375.95
NX 15, 120/30 CPS NLQ.....$ 549.95
XR 1000 300/76 CPS NLQ.....$ 595.95
XR 1500 300/76 CPS NLQ.....$ 799.95
NX 2400 170/57 CPS LQ, 24 PIN $ 499.95

AEG OLYMPIA
NPC 136-24 24 PIN 240 CPS COL $ 749.95
NP 136-24 24 PIN 240 CPS.....$ 699.95

Program Card for IBM-PC/XT/AT

BW-601 BIPOLAR PROM PROG. CARD..$399.95
EW-701 EPROM WRITER 2716-1024...$299.95
EW-704 EPROM WRITER 2716-1024...$349.95
EW-901 EPROM WRITER XT/AT 2716-512 $249.95
EW-904 EPROM WRITER XT/AT 2716-512 $325.95
PAP-01 PAL PROGRAMMER.....$399.95
BPP-01 BPROM PROGRAMMER.....$399.95
BU-201/T EPROM U. V. ERASER.....$149.95

INTERFACE CONVERTER
SMITH CORONA SERIAL-PARALLEL..$ 49.95
SP-100 SER-PAR, EXT POWERED...$ 89.95
PS-100 PAR-SER, EXT POWERED...$ 89.95
SP-200 SER-PAR, INTERFACE POW $ 79.95
PS-200 PAR-SER, INTERFACE POW $ 79.95
RR-100 RS232C/RS422A CONVERT..$ 69.95
IC-11 RS232C/RS485 CONVERTER..$ 99.95
IC-12 RS232C/CURRENT LOOP CON $ 99.95

MOTHER BOARDS

XT 8MHz TURBO MB OK.....$ 99.95
XT 10MHz TURBO MB OK.....$ 109.95
XT 16 MH TURBO MB OK.....$ 129.95
AT 286 6/12 TURBO MB OK.....$ 249.95
AT BABY 286 8/16 OK.....$ 289.95
AT 16 MH MEG EMS OK.....$ 299.95
NEAT 286 16MHz OK.....$ 599.95
386 SX 16MHz.....$ 599.95
386 16/20MHz OK.....$ 999.95
386 16/25MHz OK.....$1,095.95
386 25MHz W/32K CACHE OK.....$1,995.45
PS/2 COMP ALL IN ONE MB.....$ 1695.95
ALL 286/386 ARE BABY SIZE TURBO M.B.

Video boards

MGA MONO GRAPHIC W/PR PORT....$ 49.95
CGA COLOR GRAPHIC W/RGB COMP..$ 49.95
MGA/CGA DUAL GRAPHIC CARD.....$ 79.95
G8 MGA/CGA AUTO SWITCH.....$ 89.95
EGA CARD 640 X 350 256K.....$ 149.95
SUPER EGA 800/600/350 8 BIT...$ 169.95
VGA CARD (8 BIT).....$ 179.95
VGA CARD (16 BIT).....$ 199.95
JUKO EGA 640 X 480.....$ 139.95

EGAWONDER

MULTI GRAPHIC SOLUTION....$ 89.95
MULTI GRAPH SOL GAME PORT $ 99.95
MULTI EGA SOLUTION.....$ 249.95
MULTI VGA SOLUTION.....$ 299.95
VGA SMALL WONDER.....$ 225.95
MAXI VGA SOL 256K/M.....$ 379.95
MAXI VGA SOL 512K/M.....$ 449.95

STB TTX GROUP

STB Systems, Inc

STB AUTO EGA.....$ 169.95
STB AUTO VGA.....$ 199.95
STB VGA EXTRA/EM256KB.....$ 259.95
STB VGA EXTRA/EM512KB.....$ 325.95
STB VGA EM 16/256KB.....$ 275.95
STB VGA EM 16/512KB.....$ 349.95

Keyboards

AT/XT 5060 STANDARD.....$ 59.95
AT/XT ENHANCED KEYBOARD.....$ 69.95

Add on boards

XT PAR PRINTER PORT.....$ 29.95
XT RS232 SERIAL PORT.....$ 34.95
XT RS422 SERIAL PORT.....$ 119.95
XT I/O + 2 (S/P/C/G).....$ 69.95
XT MULTI I/O (S/P/C/G/DISK)...$ 79.95
XT GAME PORT (TWO PORT).....$ 29.95
XT TIME CARD.....$ 39.95
AT I/O S/P NO GAME PORT.....$ 49.95
AT I/O S/P/G.....$ 59.95
AT I/O 2 S/P/G.....$ 79.95
AT GAME PORT.....$ 49.95

Power supplies

150W CSA XT SIZE.....$ 79.95
200W CSA XT SIZE.....$ 89.95
200W CSA FULL SIZE.....$ 99.95
200W CSA FOR TOWER CASE.....$ 139.95
PS/2 STYLE CASE.....$ 99.95
SMALL FOOT PRINT CASE.....$ 99.95
DESKTOP TOWER CASE.....$ 139.95

COMPUTER CASES

AT STYLE CASE, XT,BABY,AT MB..$ 59.95
AT FULL SIZE CASE.....$ 89.95
SMALL FOOT PRINT AT OR XT.....$ 89.95
PS/2 STYLE CASES.....$ 89.95
TOWER CASE AT,XT OR 386 FULL $ 189.95
TOWER MINI DESKTOP AT,XT,386 $ 189.95

DISKETTE STORAGE BOXES

DD-5 HOLDS 5 DISKS.....$ 2.95
DD-10 HOLDS 10 DISKS.....$ 3.95
DD-50 HOLDS 50 DISKS.....$ 8.95
DD-70 HOLDS 70 DISKS.....$ 9.95
DD-100L HOLDS 100 DISKS.....$12.95
DD-120L HOLDS 120 DISKS.....$13.95
DD-140L HOLDS 140 DISKS.....$14.95
DD-180L HOLDS 180 DISKS.....$39.95
CARDBOARD MAILER PKG/25.....$26.95

DISKETTE HOLDERS FOR 3½" DISKS
YD-5 HOLDS 5 DISKS.....$ 2.95
YD-10 HOLDS 10 DISKS.....$ 3.95
YD-20 HOLDS 20 DISKS.....$ 7.95
YD-40 HOLDS 40 DISKS.....$10.95
YD-80 HOLDS 80 DISKS.....$12.95
YD-150 HOLDS 150 DISKS.....$39.95
CARDBOARD MAILER PKG/25.....$24.95

PLEASE ASK FOR OUR FREE CATALOG

TERMS VISA/MC/COD/CHEQUE
ALL ITEMS SHIPPED BY CANPAR OR MAIL. ADD $4.00 FOR ALL COD ORDERS. ALLOW 10 BUSINESS DAYS FOR SHIPPING WHEN PAYING BY PERSONAL CHEQUE. ALL ITEMS SUBJECT TO PRIOR SALE DELIVERY & HANDLING CHARGE 6%, MIN. $5.00 ALL RETURNED MERCHANDISE MUST HAVE RMA NUMBER. RESTOCKING CHARGE 20%. PRICE SUBJECT TO CHANGE WITHOUT ANY NOTICE.

CREDIT CARD CHARGES ARE NOT SUBMITTED UNTIL TIME OF SHIPMENT.

WHY WAIT? CALL ORION ELECTRONICS NOW!
ORDER TOLL FREE
1-800-265-2658

VISA MasterCard

Order desk & technical support open:
9.00 a.m. to 6.00 p.m. Monday - Friday
9.00 a.m. to 5.00 p.m. Saturday
For Service CALL
1-519-576-9026

40 LANCASTER ST., W. KITCHENER, ONT. N2H 4S9 PH: (519) 576-9902 FAX: (519) 576-9028

DEALER INQUIRIES INVITED

IMMEDIATE SHIPMENT ON PURCHASE ORDERS FROM QUALIFIED INSTITUTIONS (SCHOOLS, UNIVERSITIES AND GOVERNMENT INCLUDED)

FOR IMMEDIATE ACTION USE OUR FAX

Circle No. 69 on Reader Service Card

PIN IT DOWN!

- INCREASE FUND-RAISING PROFITS!
- BUILD TEAM SPIRIT!
- RECOGNIZE VOLUNTEERS!
- REWARD YOUR EMPLOYEES!
- GET YOUR COMPANY NAME AROUND!

At The Pin Factory, we can help you pin down your business with our custom lapel pins, charms, key chains, souvenir spoons, belt buckles, money clips and other pressed metal products, manufactured with the newest production equipment available.

We can help you create your own special "one-of-a-kind" item. Special die cutting will give your item a custom shape, in virtually any colour of the rainbow. Choose from our wide range of production materials, including precious and semi-precious metals.

We give competitive pricing, quality products and efficient, courteous service on all your orders, large or small! So call us today and let us show you how we can help you pin it down!

THE PIN FACTORY

9752 — 47 Avenue, Edmonton, Alberta T6E 5P3
Phone: (403) 435-5944 FAX: (403) 437-4105

Circle No. 130 on Reader Service Card